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Fatty Acid Carbon Chain Length as a Determinant of Lymphatic versus Portal Transport and its Implications for Selecting Fat Components in Athletes' Diets

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Abstract

Dietary fat in the diets of athletes is planned through its share of daily energy, and the route that a fatty acid follows after absorption seldom enters that calculation. The present review treats carbon chain length as the variable that sorts absorbed fatty acids into two transport routes and carries this physiology into the choice of fat sources for bodybuilding and fitness athletes. Medium-chain fatty acids C8 and C10 leave the enterocyte without re-esterification, travel in portal blood, and reach the liver first, where they undergo rapid oxidation. Fatty acids of C14 and longer are packaged into chylomicrons and enter the systemic circulation via the intestinal lymph and the thoracic duct, so skeletal muscle, the heart, and adipose tissue receive them before the liver does. Lauric acid, C12, sits at the border between the two groups. Chemistry classifies it as a medium-chain acid, whereas transport data indicate that most of it is transported via the lymphatic route, which explains why coconut oil cannot serve as a substitute for medium-chain triglyceride oil. A functional taxonomy built on chain length, route, speed of availability, dietary role, and tolerance groups the fats used in physique sports and links them to the off-season, cutting, and peak week. Long-chain sources such as olive oil, avocado, nuts, flax, and chia form the basis of fat intake because they sustain satiety, support the delivery of fat-soluble vitamins, provide omega-3s, and maintain hormonal status. Transport route says nothing about safety within the long-chain group. Industrial trans fatty acids from partially hydrogenated fats carry cardiometabolic harm and have no place in the diet in any phase, whereas saturated myristic and palmitic acids become a concern at excessive intakes typical of fatty processed meat and fast food. Medium-chain triglyceride oil occupies a narrow niche as a fast energy substrate on low-carbohydrate days, within a ceiling set by gastrointestinal tolerance. Chain length thus gives sports medicine a second criterion for fat selection that complements the energy share and turns a percentage target into a set of physiological decisions about which fat, when, and for what purpose.

Keywords: *Athletes' Diet, Chylomicrons, Fatty Acid Chain Length, Medium-Chain Triglycerides, Sports Medicine.*

INTRODUCTION

Fat planning in sports nutrition rests on energy arithmetic. The joint position statement of the American College of Sports Medicine, the Academy of Nutrition and Dietetics and Dietitians of Canada scales carbohydrate and protein targets to body mass and training load, whereas fat receives a single band of 20% to 35% of daily energy taken over from public health guidance (Thomas et al., 2016). The fat component of an athlete's diet is therefore defined by a percentage band and a list of sources labeled as healthy, and no physiological criterion explains why one fat suits a given phase of preparation better than another.

Physiology supplies such a criterion at the first step of fat metabolism. After hydrolysis in the small intestine, fatty acids separate according to the length of their carbon chains. Long-chain acids are re-esterified into triglycerides, assembled into chylomicrons, and secreted into lacteals, from where lymph carries them through the thoracic duct into venous blood and spares them a first passage through the liver (Zhang et al., 2021). Medium-chain acids bypass re-esterification and chylomicron assembly, reaching the liver via portal blood (Watanabe & Tsujino, 2022). The two routes differ in timing, in the first organ to encounter the fatty acid, and in its metabolic fate; each of these differences shapes how a fat behaves in an athlete's diet.

The practical gap opens where sports nutrition meets the retail shelf. Medium-chain triglyceride oil, known in commerce as MCT oil, and coconut oil are often treated as a single class, and the term MCT itself denotes C8 alone in some papers, C8 and C10 in others, and the full C6-C12 range in still others (Norgren et al., 2024). Firsthand consulting practice with bodybuilding and fitness athletes since 2023, which covers individual training and nutrition programs and competition preparation, runs into this confusion at every stage of preparation, where the choice between a fast portal substrate and a lymphatic structural fat has to be made in grams on a plate. Direct judging work within the Belarusian Federation of Bodybuilding and Fitness since 2024 provides

the endpoint against which such choices are tested: the athlete's stage condition.

In the reviewed literature, no classification was found that links fatty acid chain length and absorption route to fat selection across the off-season, cutting, and peak week. The present review addresses this gap with three aims. The first aim is to describe the lymphatic and portal routes, along with the factors that direct a fatty acid toward one of them. The second aim is to classify the dietary fats used in physique sports by chain length and route. The third aim is to derive a selection matrix for the three phases of contest preparation that connects route physiology with concrete decisions about fat sources, portions, and timing.

MATERIALS AND METHODS

The work is a narrative review with taxonomic synthesis. Its products are a classification of dietary fat components by chain length and transport route and a selection matrix for contest preparation phases, and quantitative pooling of effect sizes lies outside its design.

The literature search covered PubMed, Google Scholar, and the Cochrane Library, using combinations of the terms fatty acid chain length, lymphatic transport, portal transport, chylomicron, medium-chain triglycerides, lauric acid, coconut oil, exercise, bodybuilding, contest preparation, and peak week. Priority went to reviews, systematic reviews, and expert documents published from 2021 to June 2024. One classic animal study with direct measurement of lymphatic recovery of individual medium-chain fatty acids was retained, since later work has not repeated such measurements, together with the joint position statement on nutrition and athletic performance and a mechanistic review of medium-chain fatty acid metabolism, which remain standard references on their points. Meta-analyses and reviews on trans and saturated fatty acids published from 2003 to 2020 were also retained, since they remain the reference evidence on the cardiometabolic effects of these acids. Mechanistic papers on transport routes, studies of medium-chain triglycerides in exercise and documents on dietary fat in athletes met the inclusion criteria. Papers devoted to lymphatic drug delivery alone were excluded. Short-chain fatty acids of microbial origin received a single mention, because they arise in the colon and do not belong to the dietary fat selection discussed here.

The taxonomy uses seven axes: chain length, transport route, speed of availability, metabolic fate, role in the diet, preparation phase, and tolerance. Estimates of the portal share of each fat source were obtained by multiplying the product's typical fatty acid composition by the fraction of each acid that escapes lymphatic recovery in rats, with C4 and C6 acids assigned to the portal route as a whole (Mu & Høy, 2000).

Decisions taken in first-hand practice, including the choice of sources for each phase, portion sizes, the starting dose of MCT oil, and the shift in the fat share in step with the carbohydrate quota, were presented alongside the literature data as examples of application.

The work combines a review of published data with first-hand practice and contains no original measurements or study sample, so observations from practice are reported as consulting experience and do not carry the status of research results. The paper provides guidance for diet design and contains no clinical prescriptions; any correction of an athlete's diet remains the responsibility of a physician and a sports dietitian.

RESULTS

Chain Length as a Transport Criterion

Boundaries between chain-length classes differ among sources. A common chemical convention places acids up to C6 among short-chain acids, C6 to C12 among medium-chain acids, and C14 and longer among long-chain acids, and commercial labeling of MCT products follows this convention with considerable freedom (Norgren et al., 2024). Transport physiology does not follow the chemical boundary at C12, which makes a functional classification by route more useful for diet design than a structural one. Fig. 1 traces the two routes from the lumen of the small intestine to the tissues that receive the absorbed fatty acids.

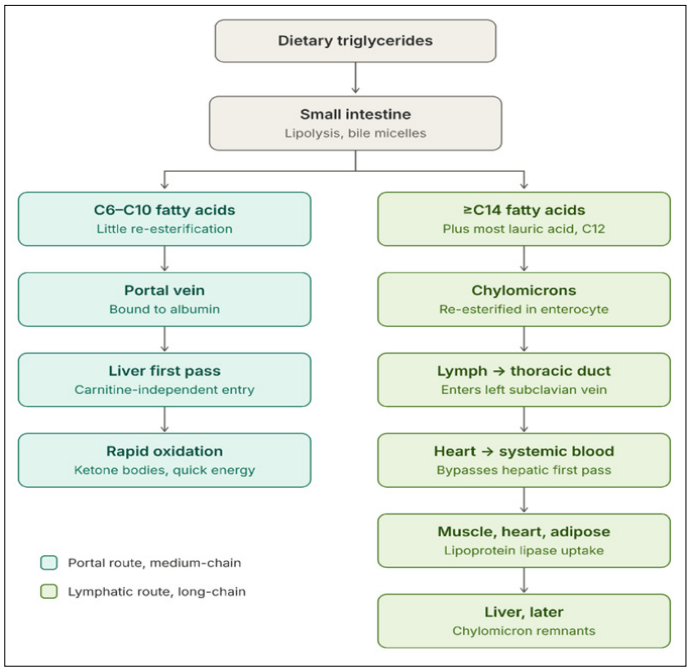


Fig. 1. Lymphatic and portal routes of dietary fatty acids after absorption in the small intestine

The Lymphatic Route

Long-chain fatty acids enter the enterocyte from mixed micelles, undergo re-esterification into triglycerides in the endoplasmic reticulum, and join apolipoprotein B-48 in the assembly of chylomicrons, which the cell secretes toward the lacteal (Levy et al., 2021). Inherited defects of this assembly

line present with fat malabsorption and deficits of fat-soluble vitamins, which reveals the dependence of vitamin delivery on the chylomicron pathway (Levy et al., 2021). The lacteals pass chylomicrons into the mesenteric lymph, which collects in the thoracic duct, and the duct empties into the left subclavian vein, so the particles travel through the right heart and the pulmonary circulation before entering the systemic arteries (Zhang et al., 2021). Lipoprotein lipase in the capillaries of skeletal muscle, the heart, and adipose tissue hydrolyzes chylomicron triglycerides, and the liver receives what remains in the form of chylomicron remnants at a later stage (Wu et al., 2021; Zhang et al., 2021). The same bypass of the hepatic first pass has attracted interest in pharmacology as a means of delivering lipid-soluble drugs, underscoring how distinct the destinations of the two routes are (Zhang et al., 2021).

The Portal Route

Medium-chain fatty acids C8 and C10 cross the enterocyte without re-esterification and without chylomicron assembly, bind partly to albumin, and reach the liver with portal blood (Schönfeld & Wojtczak, 2016; Watanabe & Tsujino, 2022). In hepatocytes, they enter mitochondria via passive diffusion, bypassing the carnitine shuttle required by long-chain fatty acids, and this pair of metabolic shortcuts enables rapid β-oxidation and the potential for ketone body production (Norgren et al., 2024). The same analysis shows that the shortcuts alone do not guarantee nutritional ketosis, and that the ketogenic effect of medium-chain products is attributable more to C8 than to longer medium-chain acids (Norgren et al., 2024). Short-chain fatty acids produced by the colonic microbiota also travel to the liver via the portal blood, although their origin places them outside dietary fat selection.

Modifiers of the Route and the Case of Lauric Acid

Direct measurement in rats demonstrates that chain length works as a gradient. Lymphatic recovery of caprylic acid C8 reached 7.3%, that of capric acid C10 reached 26.3%, and lauric acid C12 reached 81.7% (Mu & Høy, 2000). Capric acid therefore splits between the two routes, and lauric acid behaves in transport as a long-chain acid despite its chemical classification. These values came from structured triglycerides that carried a long-chain acid at the middle position of the glycerol, so the molecular context of a medium-chain acid also influences the balance between lymph and portal blood (Mu & Høy, 2000). Lauric acid may also undergo elongation to longer-chain acids in a carbohydrate-fed state, thereby reducing its contribution to rapid hepatic oxidation (Norgren et al., 2024).

Fat Sources through the Lens of Chain Length

Commercial MCT oil consists of C8 and C10 acids in a ratio of about 60:40, yielding an estimated portal share of about 85%. Lauric acid accounts for about half of the fatty acids in coconut oil (Norgren et al., 2024). With C8 and C10 together near 15% and acids of C14 and longer near 37%, coconut oil delivers about 21% of its fatty acids through the portal route. Ghee contains about 11% C4-C10 acids, along with traces of lauric acid, and its estimated portal share remains near 11%. Olive oil, avocado, almonds, walnuts, flax and chia consist of C16 and C18 acids with traces of shorter ones, so their portal share remains below 1%. Fig. 2 sets these compositions side by side and shows the estimated portal share for each source.

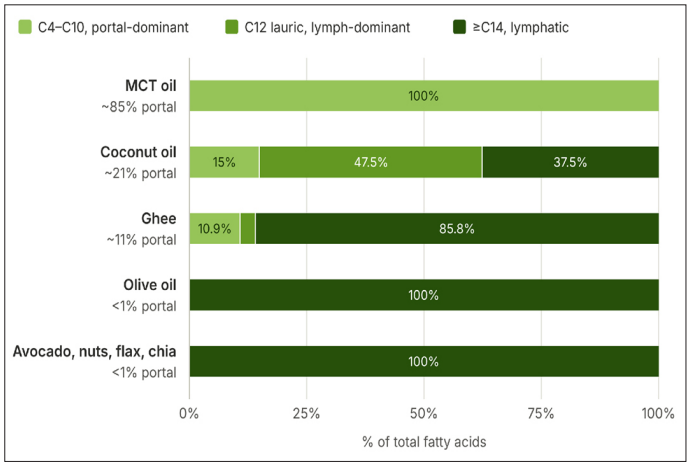


Fig. 2. Chain-length composition of dietary fat sources and estimated share of fatty acids transported by the portal route

DISCUSSION

Coconut oil and MCT Oil as Different Tools

The estimates place coconut oil among lymphatic fats with a modest medium-chain admixture, and this conclusion agrees with metabolic data. A dose of 30 g of coconut oil did not raise blood β-hydroxybutyrate compared with sunflower oil, and the analysis of this result located the ketogenic potential of medium-chain products in C8 (Norgren et al., 2024). Two products that share shelf space and marketing vocabulary thus perform different physiological tasks. Firsthand practice reflects this division by using coconut oil in small amounts as a culinary fat for athletes with good tolerance, while MCT oil serves as a fast-acting energy substrate on low-carbohydrate days.

Long-Chain Fats as the Base of Fat Intake

The lymphatic route explains why long-chain fats carry most of the functional load of the fat component. Chylomicrons are the vehicles for fat-soluble vitamins, and disorders of chylomicron assembly reveal the dependence of vitamin status on these vehicles (Levy et al., 2021). Omega-3 supply follows the same route. Ground flax and chia provide alpha-linolenic acid, ALA, whose conversion in humans yields limited amounts of eicosapentaenoic and docosahexaenoic acids, EPA and DHA, and the evidence for benefits in athletes concerns EPA and DHA themselves (Tomczyk et al., 2023). Hormonal status forms the third argument. A meta-analysis of six intervention studies in men found lower total

testosterone on low-fat diets than on high-fat diets, with a standardized mean difference of −0.38, and free testosterone showed the same pattern (Whittaker & Wu, 2021). Appetite regulation adds a fourth dimension, because experiments in mice tie the specific appetite for medium-chain triglycerides to hepatic β-oxidation of medium-chain acids, a signal that long-chain fats do not generate (Maruyama et al., 2024). Fats that enter the body by different routes therefore send different signals to the systems that control food intake.

Trans and Saturated Long-Chain Fatty Acids

Transport route groups long-chain acids by the way they reach tissues and says nothing about their cardiometabolic safety, which depends on saturation and on the geometry of double bonds. Industrial trans fatty acids, which arise during partial hydrogenation of vegetable oils and occur in hard margarines, shortenings, commercial baked goods and deep-fried fast food, form the group with the most consistent evidence of harm. They raise low-density lipoprotein cholesterol, lower high-density lipoprotein cholesterol, promote systemic inflammation and impair endothelial function, and an intake of 2% of daily energy corresponds to a 23% higher incidence of coronary heart disease (Mozaffarian et al., 2006). Per unit of energy, trans isomers worsen the ratio of total to high-density lipoprotein cholesterol more than saturated fatty acids do (Mensink et al., 2003). A meta-analysis of observational studies linked total trans fat intake with 34% higher all-cause mortality and 28% higher coronary mortality, and the association with coronary heart disease belonged to industrial trans fats, while ruminant trans fats from dairy and meat showed no such association (de Souza et al., 2015). Industrial trans fats therefore have no functional role in an athlete's diet, and the selection matrix excludes them in every phase of preparation.

Saturated long-chain acids call for a graded view. Myristic acid C14:0 and palmitic acid C16:0 raise low-density lipoprotein cholesterol, stearic acid C18:0 leaves it close to neutral, and lauric acid raises high-density lipoprotein cholesterol enough to lower the ratio of total to high-density lipoprotein cholesterol (Mensink et al., 2003). In pooled cohort data, saturated fat intake showed no association with all-cause mortality, cardiovascular disease, coronary heart disease, ischemic stroke or type 2 diabetes (de Souza et al., 2015). Randomized trials that lowered saturated fat intake reduced combined cardiovascular events by 17%, and the benefit grew with the size of the reduction and when polyunsaturated fat replaced the saturated fat removed (Hooper et al., 2020). The food matrix also shapes the outcome, since saturated fat delivered by whole-fat dairy, unprocessed meat and dark chocolate shows no link with higher cardiovascular risk, which supports food-based recommendations as a complement to the cap of 10% of daily energy from saturated fat (Astrup et al., 2020). Myristic and palmitic acids thus turn harmful at excessive intakes, and in everyday eating such intakes come from fatty processed meat and fast food, where frying fats can add trans isomers on top of the saturated load.

In the selection matrix, saturated fat enters through ghee and coconut oil in limited and small amounts, while the base of the fat component rests on monounsaturated and polyunsaturated sources, so saturated intake stays moderate in all three phases. First-hand practice keeps refined oils, fried foods and fast food to a minimum, which removes the main dietary carriers of industrial trans fats and of excess palmitic acid at the same time. Table 1 lists industrial margarines and shortenings in a separate row excluded from every phase.

Medium-Chain Triglyceride Oil in Athletes

A systematic review of MCT oil supplementation in healthy populations found little to no ergogenic effect on endurance performance and substrate utilization, and that the ketones produced after intake did not serve as a major fuel during acute endurance exercise (Chapman-Lopez & Koh, 2022). The same review identified 30 g as the upper dose that minimizes adverse effects during and after exercise (Chapman-Lopez & Koh, 2022). Data on muscle function and endurance in favor of medium-chain triglycerides come from cell and animal models, as well as small trials in older adults or clinical groups (Watanabe & Tsujino, 2022). The niche of MCT oil in physique sports is therefore narrow. Firsthand practice uses it as a fast energy source in low-carbohydrate protocols, when work capacity has to be maintained without a large food volume, and it begins with 5 to 10 g, since some athletes react to MCT oil with gastrointestinal discomfort. The starting dose is a third of the 30 g ceiling or less, leaving room for upward titration guided by tolerance.

Selection Matrix across Preparation Phases

Table 1 brings route physiology and first-hand decisions together into a selection matrix for the off-season, cutting, and peak week. During the off-season, with base training loads and goals of maintenance or mass gain, the fat component draws on extra virgin olive oil added to prepared dishes, avocado as a steady source of monounsaturated fat and fiber, almonds and walnuts, ground flax and chia for ALA, and ghee for athletes without sensitivity to dairy. Refined oils and fried foods are kept to a minimum in every phase. The cutting phase uses the same sources at a lower volume, with the goal of preserving hormonal status and the absorption of fat-soluble vitamins without adding calories that provide no functional benefit. A typical daily set in this phase consists of one to two tablespoons of olive oil plus half an avocado or a handful of nuts. MCT oil enters the cutting phase as an option for low-carbohydrate days.

Peak week narrows the choice to the most predictable fats, olive oil and avocado. Nuts and seeds are removed from the menu because their fiber content increases the risk of digestive discomfort and fluctuations in abdominal volume when the athlete steps on stage. The main levers of peak

week are manipulations of carbohydrate, water, and sodium (Escalante et al., 2021). Fat selection in this phase serves the stability of digestion, so that these levers act on a calm gastrointestinal background.

Table 1. Selection matrix of dietary fat components across phases of contest preparation

Component	Main chain length	Route and availability	Role in the diet	Off-season	Cutting	Peak week	Tolerance
Extra virgin olive oil	C18:1	Lymphatic, slow	Monounsaturated base, carrier of fat-soluble vitamins	Added to prepared dishes	One to two tablespoons per day	Main fat	Good
Avocado	C18:1	Lymphatic, slow	Satiety, fiber, carotenoid uptake	Included	Half a fruit or nuts	Main fat	Good
Almonds, walnuts	C18 acids, ALA in walnuts	Lymphatic, slow	Satiety, micronutrients	Included	A handful or avocado	Excluded	Fiber load
Ground flax, chia	C18:3, ALA	Lymphatic, slow	Plant omega-3 source	Included	Reduced amount	Excluded	Fiber load
Ghee	C14 and longer, about 11% C4–C10	Lymphatic with a portal fraction, slow	Culinary fat with trace milk protein	Without dairy sensitivity	Limited	Not used	Dairy sensitivity
MCT oil	C8–C10	Portal, fast	Fast substrate on low-carbohydrate days	Seldom	Starting dose of 5–10 g	Not used	Dose-dependent gut symptoms
Coconut oil	About half C12	Lymphatic with a portal fraction, intermediate	Culinary fat, no substitute for MCT oil	Small amounts	Small amounts	Not used	Individual
Industrial margarines, shortenings	C18:1 trans	Lymphatic, slow	No functional role, cardiometabolic harm	Excluded	Excluded	Excluded	Not applicable

Fat Share and the Carbohydrate Quota

Firsthand practice sets the fat component according to functional criteria, among which hormonal status, satiety, absorption of fat-soluble vitamins, stable energy, and digestive comfort carry the most weight. These criteria translate into 20% to 35% of daily energy intake, with the exact value determined by the carbohydrate quota. On high-carbohydrate days, the fat share falls, and on low-carbohydrate days, it rises, using whole foods without spreading added oil across every meal. The lower end of this band overlaps with the meta-analytic signal for testosterone, since prolonged reductions in fat intake are associated with lower androgen levels in men (Whittaker & Wu, 2021). Markers of a correct setting include the absence of sharp energy swings, good sleep, stable bowel function, and the absence of edema or bloating.

Observations from Practice

Records from first-hand practice describe four groups of responses to a fat component based on whole-plant sources and a minimum of refined oils and ultra-processed fats. Tolerance improves in athletes whose previous diet contained a lot of fried foods and refined oils, with less bloating and abdominal discomfort, while some athletes report transient discomfort at the start of the transition due to increased fiber and whole-food fats. Energy levels become more even and lose their sharp dips, although the first weeks on a low-carbohydrate background can bring a temporary decline in work capacity. Appetite stays under control for long periods after meals that combine fat with fiber, which helps during the cutting phase. Changes in body composition under an adequate caloric deficit show a steady loss of fat mass, but the pace of change can lag that seen on diets built on ultra-processed foods; the larger volume of whole-food meals may account for this difference.

Significance for Sports Medicine

Chain length adds a physiological dimension to fat planning that energy percentages cannot provide. A team that includes a sports physician, a dietitian, and a coach gains a shared vocabulary in which a fat source is described by its route, its speed of availability, and its function, and this vocabulary resolves the confusion between products such as coconut oil and MCT oil. The route criterion also helps with reading product labels because the term MCT encompasses different sets of acids in different contexts (Norgren et al., 2024). Expert guidance on athlete nutrition defines fat intake mainly as a share of daily energy (Thomas et al., 2016). A route-based taxonomy offers one way to fill this space with decisions that remain traceable to physiology.

LIMITATIONS

The review rests on published data combined with first-hand practice and contains no original measurements or study sample; therefore, observations from practice represent

consulting experience rather than research results. The paper provides grounds for diet design and includes no clinical prescriptions, and any correction of an athlete's diet requires supervision by a physician and a sports dietitian.

CONCLUSION

Carbon chain length determines the route of a dietary fatty acid after absorption. Medium-chain acids C8 and C10 travel with portal blood to the liver and serve as a fast oxidative substrate, whereas acids of C14 and longer enter chylomicrons and reach muscle, the heart, and adipose tissue through lymph before the liver receives their remnants. Lauric acid is primarily delivered via the lymphatic route, so coconut oil functions as a lymphatic fat with a modest medium-chain admixture and cannot replace MCT oil. In athletes' diets, long-chain fats from olive oil, avocado, nuts, flax, and chia form the basis of fat intake during the off-season and cutting, while peak week narrows the choice to olive oil and avocado. Chain length does not grade safety, so industrial trans fatty acids stay out of the diet in every phase, and saturated myristic and palmitic acids remain acceptable at moderate intakes from whole foods, with their risk concentrated in fatty processed meat and fast food. MCT oil holds a narrow niche on low-carbohydrate days, with a small starting dose and a ceiling set by gastrointestinal tolerance. In sports medicine, the transport route becomes a second criterion for fat selection alongside the energy share, and the proposed matrix translates this criterion into decisions about fat sources for each phase of contest preparation.

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