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FETTE IM AUSDAUERSPORT

Fördern oder mindern sie die Leistung?

Sportarten		Energie (kcal/d)	KH (g/kg/d)	Proteine (g/kg/d)	Fette (En%)	Land	Autoren
SOLL-Werte		bedarfs-angepasst	8–12	1,2–1,4	20–30	USA	Thomas et al. (2016)
Ausdauersport							
Laufen	26 ♂♀	2419	5,1	1,4	33,1	FRA	Garcin et al. (2009)
	8 ♂	2946	7,4	1,7	25,3	NED	Wardenaar et al. (2017)
	11 ♀	2299	5,6	1,8	29,0		
Berglaufen	6 ♀♂	3199	8,3	1,6	24	GER	Carlsohn & Müller (2014)
Schwimmen	1 ♂	4350	7,5	2,1	34	GER	Carlsohn et al. (2011)
	11 ♂	3067	5,0	1,6	26,6	NED	Wardenaar et al. (2017)
	9 ♀	2495	5,3	1,6	26,0		
Triathlon	15 ♂	2662	4,6	1,4	33,0	USA	Drenowatz et al. (2012)
+ Straßenrad	10 ♀	2821	6,7	2,3	26,8	AUS	Heaney et al. (2010)
Straßenrad	34 ♂	2735	5,5	1,7	27,1	NED	Wardenaar et al. (2017)
	14 ♀	2127	4,2	1,5	29,0		
Profi-Radrundfahrten							
Tour Andalusia	6 ♂	5644	12,8	3,0	23	ESP	Sánchez-Muñoz et al. (2016)
Tour Southland	5 ♂	6528	12,9	2,9	17,3	NZL	Rehrer et al. (2010)
Ultradistanz							
RAAM	4 ♂	4918	9,0	3,8	16	GBR	Hulton et al. (2010)
RAAM	1 ♂	9437	24,8	4,6	11	AUT	Konrad (2010)

Tabelle A: Energie- und Makronährstoffzufuhr von Elite-Ausdauersportlern aus Europa und Übersee gemäß Studien aus den Jahren 2009 bis 2017

Literatur

Angus, D. J., Hargraeves, M., Dancey, J. & Febbraio, M. A. (2000). Effect of carbohydrate or carbohydrate plus medium chain triglyceride ingestion on cycling time trial performance. *J. Appl. Physiol., 88* (1), 113-119.

Bortolotti, M., Tappy, L. & Schneiter, P. (2007). Fish oil supplementation does not alter energy efficiency in healthy males. *Clin. Nutr, 26* (2), 225-230.

Brass, E. P. (2000). Supplemental carnitine and exercise. *Am. J. Clin. Nutr., 72* (2 Suppl.), 618S-623S.

Brukner, P. (2013). Challenging beliefs in sports nutrition: are two 'core principles' proving to be myths ripe for busting? *Brit. J. Sports Med., 47* (11), 663 f.

Burke, L. M. (2015). Re-examining high-fat diets for sports performance: Did we call the 'nail in the coffin' too soon? *Sports Med., 45* (Suppl. 1), S33-S49.

Burke, L. M., Angus, D. J., Cox, G. R. et al. (2000). Effect of fat adaptation and carbohydrate restoration on metabolism and performance during prolonged cycling. *J. Appl. Physiol., 89* (6), 2413-2421.

Burke, L. M., Hawley, J. A., Angus, D. J. et al. (2002). Adaptations to short-term high-fat diet persist during exercise despite high carbohydrate availability. *Med. Sci. Sports Exerc., 34* (1), 83-91.

Burke, L. M., Ross, M. L., Garvican-Lewis, L. A. et al. (2017). Low carbohydrate, high fat diet impairs exercise economy and negates the performance benefit from intensified training in elite race walkers. *J. Physiol., 595* (9), 2785-2807.

Carey, A. L., Staudacher, H. M., Cummings, N. K. et al. (2001). Effects of fat adaptation and carbohydrate restoration on prolonged endurance exercise. *J. Appl. Physiol., 91* (1), 115-122.

Carlsohn, A., Cassel, M., Linné, K. & Mayer, F. (2011). How much is too much? A case report of nutritional supplement use of a high-performance athlete. *Br. J. Nutr., 105* (12), 1724-1728.

Carlsohn, A. & Müller, W. (2014). Anthropometry and dietary intake before and during a competition in mountain runners. *J. Nutr. Metab., 2014*: 893090 (doi: 10.1155/2014/893090).

Chang, C.-K., Borer, K. & Lin, P. J. (2017). Low-carbohydrate-high-fat diet: can it help exercise performance? *J. Hum. Kinet., 56*, 81-92.

Da Boit, M., Hunter, A. M. & Gray, S. R. (2017). Fit with good fat? The role of n-3 polyunsaturated fatty acids on exercise performance. *Metabolism, 66*, 45-54.

Décombaz, J. (2003). Nutrition and recovery of muscle energy stores after exercise. *Schweiz. Ztschr. Sportmed. Sporttraumatol., 51* (1), 31-38.

Décombaz, J., Arnaud, M.-J., Milon, H. et al. (1983). Energy metabolism of medium-chain triglycerides versus carbohydrates during exercise. *Eur. J. Appl. Physiol., 52* (1), 9-14.

Desbrow, B. & Leveritt, M. (2007). Well-trained endurance athletes' knowledge, insight, and experience of caffeine use. *Int. J. Sport Nutr. Exerc. Metab., 17* (4), 328-339.

DGE (2011). Mittelkettige Triglyceride für die Adipositastherapie nicht empfehlenswert. *DGE-info,* (2), 18-21.

DGE (2017). *Vollwertig essen und trinken nach den 10 Regeln der DGE.* Download unter http://www.dge.de/ernaehrungspraxis/vollwertige-ernaehrung/10-regeln-der-dge/.

DGE, ÖGE & SGE (2017). *Referenzwerte für die Nährstoffzufuhr* (2. Aufl., 3. Ausgabe). Bonn.

Dinter, J., Bechthold, A., Boeing, H. et al. (2016). Fischverzehr und Prävention ausgewählter ernährungsmitbedingter Krankheiten. *Ernährungs Umschau, 63* (7), 148-154.

Drenowatz, C., Eisenmann, J. C., Carlsohn, J. J. et al. (2012). Energy expenditure and dietary intake during high-volume and low-volume training periods among male endurance athletes. *Appl. Physiol. Nutr. Metab., 37* (2), 199-205.

EFSA (2003). Opinion of the Scientific Panel on Food Additives, Flavourings, Processing Aids and Materials in Contact with Food (AFC) on a request from the Commission related to L-Carnitine-L-tartrate for use in foods for particular nutritional uses. *EFSA Journal, 19*, 1-13.

EFSA (2011a). Scientific Opinion on the substantiation of health claims related to caffeine and increase in physical performance... *EFSA Journal, 9* (4), 2053.

EFSA (2011b). Scientific Opinion on the substantiation of health claims related to caffeine and increased fat oxidation... *EFSA Journal, 9* (4), 2054.

EFSA (2011c). Scientific Opinion on the substantiation of health claims related to medium-chain triglycerides and reduction in body weight… *EFSA Journal, 9* (6), 2240.
EFSA (2012). Tolerable upper intake level of EPA, DHA and DPA. *EFSA Journal, 10* (7), 2815.
EFSA NDA Panel (2011). Scientific Opinion on the substantiation of health claims related to L-carnitine… *EFSA Journal, 9* (6), 2212.
EFSA NDA Panel (2015). Scientific Opinion on the safety of caffeine. *EFSA Journal, 13* (5), 4102 ff.
Fife, B. (2014). *The Coconut Ketogenic Diet.* Colorado Springs: Piccadilly Books.
Garcin, M., Doussot, L., Mille-Hamard, L. & Billat, V. (2009). Athletes' dietary intake was closer to French RDA's than those of young sedentary counterparts. *Nutr. Res., 29* (10), 736-742.
Goedecke, J. H., Christie, C., Wilson, G. et al. (1999a). Metabolic adaptations to a high fat-diet in endurance cyclists. *Metabolism, 48* (12), 1509-1517.
Goedecke, J. H., Clark, V. L., Noakes, T. D. & Lambert, E. V. (2005). The effects of medium-chain triacylglycerol and carbohydrate ingestion on ultra-endurance exercise performance. *Int. J. Sport Nutr. Exerc. Metab., 15* (1), 15-27.
Goedecke, J. H., Elmer-English, R., Dennis, S. C. et al. (1999b). Effects of medium-chain triacylglycerol ingested with carbohydrate on metabolism and exercise performance. *Int. J. Sport Nutr., 9* (1), 35-47.
Graham, T. E., Helge, J. W., MacLean, D. A. et al. (2000). Caffeine ingestion does not alter carbohydrate or fat metabolism in human skeletal muscle during exercise. *J. Physiol., 529* (Pt 3), 837-847.
Greer, F., Friars, D. & Graham, T. E. (2000). Comparison of caffeine and theophylline ingestion: exercise metabolism and endurance. *J. Appl. Physiol., 89* (5), 1837-1844.
Gutiérrez, Á., González-Gross, M., Delgado, M. & Castillo, M. J. (2001). Three days fast in sportsmen decreases physical work capacity but not strength or perception-reaction time. *Int. J. Sports Nutr. Exerc. Metab., 11* (4), 420-429.
Hargreaves, M., Hawly, J. A. & Jeukendrup, A. (2004). Pre-exercise carbohydrate and fat ingestion: effects on metabolism and performance. *J. Sports Sci., 22* (1), 31-38.
Havemann, L., West, S. J., Goedecke, H. J. et al. (2006). Fat adaptation followed by carbohydrate-loading compromises high-intensity sprint performance. *J. Appl. Physiol., 100* (1), 194-202.
Hawley, J. A., Burke, L. M., Angus, D. J. et al. (2000). Effect of altering substrate availability on metabolism and performance during intense exercise. *Br. J. Nutr., 84* (6), 829-838.
Heaney, S., O'Connor, H., Gifford, J. & Naughton, G. (2010). Comparison of strategies for assessing nutritional adequacy in elite female athletes' dietary intake. *Int. J. Sport Nutr. Exerc. Metab., 20* (3), 245-256.
Heinonen, O. J. (1996). Carnitine and physical exercise. *Sports Med., 22* (2), 109-132.
Helge, J. W. (2017). A high carbohydrate diet remains the evidence based choice for elite athletes to optimise performance. *J. Physiol., 595* (9), 2775.
Hessvik, N. P., Bakke, S. S., Frederiksson, K. et al. (2010). Metabolic switching of human myotubes is improved by n-3 fatty acids. *J. Lipid. Res., 51* (8), 2090-2104.
Holloway, C. J., Cochlin, L. E., Emmanuel, Y. et al. (2011). A high-fat diet impairs cardiac high-energy phosphate metabolism and cognitive function in healthy human subjects. *Am. J. Clin. Nutr., 94* (3), 748-755.
Hulton, A. T., Edwards, J. P., Gregson, W. et al. (2013). Effect of fat and CHO meals on intermittent exercise in soccer players. *Int. J. Sports Med., 34* (2), 165-169.
Hulton, A. T., Lahart, I., William, K. L. et al. (2010). Energy Expenditure in the Race Across America (RAAM). *Int. J. Sports Med., 31* (7), 463-467.
Ivy, J. L., Costill, D. L., Fink, W. J. & Maglischo, E. (1980). Contribution of medium and long chain triglyceride intake to energy metabolism during prolonged exercise. *Int. J. Sports Med., 1* (1), 15-20.
Jeukendrup, A. E., Saris, W. H. M., Brouns, F. et al. (1996a). Effects of carbohydrate (CHO) and fat supplementation on CHO metabolism during prolonged exercise. *Metabolism, 45* (7), 915-921.
Jeukendrup, A. E., Saris, W. H. M., Schrauwen, P. et al. (1995). Metabolic availability of medium-chain triglycerides co-ingested with carbohydrates during prolonged exercise. *J. Appl. Physiol., 79* (3), 756-762.
Jeukendrup, A. E., Saris, W. H. M., van Diesen, R. et al. (1996b). Effect of endogenous carbohydrate availability on oral medium-chain triglyceride oxidation during prolonged exercise. *J. Appl. Physiol., 80* (3), 949-954.
Jeukendrup, A. E., Saris, W. H. M. & Wagenmakers, A. J. M. (1998a). Fat metabolism during exercise: a review. Part III: Effects of nutritional interventions. *Int. J. Sports Med., 19* (6), 371-379.
Jeukendrup, A. E., Thielen, J. J., Wagenmakers, A. J. M. et al. (1998b). Effect of MCT and carbohydrate ingestion on substrate utilization and cycling performance. *Am. J. Clin. Nutr., 67* (3), 397-404.
Köhler, M. (2013). *Verbesserung des n-3-Status durch die Supplementation von Alpha-Linolensäure und Auswirkungen auf kardiovaskuläre Risikomarker bei Probanden mit Prä-Metabolischem Syndrom.* Dissertation. Universität Jena.
Konrad, M. (2010). Nahrungsaufnahme im Radsport in Ultradistanz – Eine Fallstudie. *Ernährungs Umschau, 57* (1), 16-20.
Lambert, E. V., Goedecke, J. H., van Zyl, C. G. et al. (2001). High-fat versus habitual diet prior to carbohydrate loading: effects on exercise metabolism and cycling performance. *Int. J. Sport Nutr. Exerc. Metab., 11,* 209-225.
Lambert, E. V., Speechly, D. P., Dennis, S. C. & Noakes, T. D. (1994). Enhanced endurance in trained cyclists during moderate intensity exercise following 2 weeks adaptation to high fat diet. *Eur. J. Appl. Physiol., 69* (4), 287-293.
Lange, K. H. W. (2004). Fat metabolism in exercise – with special reference to training and growth hormone administration. *Scand. J. Med. Sci. Sports, 14* (2), 74-99.
Leckey, J. J., Hoffmann, N. J., Parr, E. B. et al. (2018). High dietary fat intake increases fat oxidation and reduces skeletal muscle mitochondrial respiration in trained humans. *FASEB J., 32* (6), 2979-2991.
Lowery, L. M. (2004). Dietary fat and sports nutrition: a primer. *J. Sport Sci. Med., 3* (3), 106-117.
Massicotte, D., Péronnet, F., Brisson, G. R. & Hillaire-Marcel, C. (1992). Oxidation of exogenous medium-chain free fatty acids during prolonged exercise: comparison with glucose. *J. Appl. Physiol., 73* (4), 1334-1339.
McSwiney, F. T., Wardrop, B., Hyde, P. N. et al. (2018). Keto-adaptation enhances exercise performance and body composition responses to training in endurance athletes. *Metabolism, 81,* 25-34.
Mickleborough, T. D., Murray, R. L., Ionescu, A. A. & Lindley, M. R. (2003). Fish oil supplementation reduces severity of exercise-induced bronchoconstriction in elite athletes. *Am. J. Respir. Crit. Care Med., 168* (10), 1181-1189.
Møller, N. & Jørgensen, J. O. L. (2009). Effects of growth hormone on glucose, lipid, and protein metabolism in human subjects. *Endocr. Rev., 30* (2), 152-177.
Noakes, T. (2004). Fat adaptation and prolonged exercise performance. *J. Appl. Physiol., 96* (3), 1243 f.
Noreen, E. E., Sass, M. J., Crow, M. L. et al. (2010) Effects of supplemental fish oil on resting metabolic rate, body composition, and salivary cortisol in healthy adults. *J. Int. Soc. Sports Nutr., 7*: 31 (doi:10.1186/1550-2783-7-31).
O'Keeffe, K. A., Keith, R. E., Wilson, G. D. & Blessing, D. L. (1989). Dietary carbohydrate intake and endurance exercise performance of trained female cyclists. *Nutr. Res., 9* (8), 819-830.
Okano, G., Sato, Y. & Murata, Y. (1998). Effect of elevated FFA levels on endurance performance after a single fat meal ingestion. *Med. Sci. Sports Exerc., 30* (5), 763-768.
Okano, G., Sato, Y., Takumi, Y. & Sugawara, M. (1996). Effect of 4-h pre-exercise high carbohydrate and high fat meal ingestion on endurance performance and metabolism. *Int. J. Sports Med., 17* (7), 530-534.
Olivecrona, T. & Bengtsson-Olivecrona, G. (1989). Heparin and Lipases. In D. Lane & U. Lindahl (eds.), *Heparin* (pp. 335-361). London: Edward Arnold Publishers.
Oliver, S. J., Laing, S. J., Wilson, S., Bilzon, J. L. & Walsh, N. (2007). Endurance running performance after 48 h of restricted fluid and/or energy intake. *Med. Sci. Sports Exerc., 39* (2), 316-322.
Paoli, A., Grimaldi, K., D'Agostino, D. et al. (2012). Ketogenic diet does not affect strength performance in elite artistic gymnasts. *J. Int. Soc. Sports Nutr., 9* (1): 34 (doi: 10.1186/1550-2783-9-34).
Pfaff, E. (2017). „Für jedes Race Across America hatte ich ein Ernährungskonzept." Interview mit Andrea Clavadetscher, Radsportler und Sieger des Race Across America (RAAM). *Leistungssport, 47* (6), 27-31.
Phinney, S. D., Bistrian, B. R. & Evans, W. F. (1983). The human metabolic response to chronic ketosis without caloric restriction: preservation of submaximal exercise capacity with reduced carbohydrate oxidation. *Metabolism, 32* (8), 769-776.
Pitsiladis, Y. P., Smith, I. & Maughan, R. J. (1999). Increased fat availability enhances the capacity of trained individuals to perform prolonged exercise. *Med. Sci. Sports Exerc., 31* (11), 1570-1579.
Rehrer, N. J., Hellemanns, I. J., Rolleston, A. K. et al. (2010). Energy intake and expenditure during a 6-day cycling stage race. *Scand. J. Med. Sci. Sports, 20* (4), 609-618.
Romjin, J. A., Coyle, E. F., Sidossis, L. S. et al. (1993). Regulation of endogenous fat and carbohydrate metabolism in relation to exercise intensity and duration. *Am. J. Physiol., 265* (3 Pt 1), E380-E391.
Rowlands, D. S. & Hopkins, W. G. (2002). Effects of high-fat and high-carbohydrate diets on metabolism and performance in cycling. *Metabolism, 51* (6), 678-690.
Sánchez-Muñoz, C., Zabala, M. & Muros, J. J. (2016). Nutritional intake and anthropometric changes of professional road cyclists during a 4-day competition. *Scand. J. Med. Sci. Sports, 26* (7), 802-808.
Schek, A. (1994). Ist eine L-Carnitin-Substitution bei Sportlern sinnvoll? *Leistungssport, 24* (2), 29-359.
Schek, A. (1997). *Modell zur Quantifizierung der Energiebereitstellung aus Fett und Kohlenhydraten in Abhängigkeit von der Belastungsintensität bei Ausdauersportlern mit unterschiedlichen Belastungsniveaus.* Niederkleen: Wissenschaftlicher Fachverlag Dr. Fleck.
Schek, A. (2017). Reduktionsdiäten – den Wald vor lauter Bäumen. *Leistungssport, 47* (6), 32-34.
Schek, A. (2018a). Ernährung im Kraftsport. *Leistungssport, 48* (6), 22-26.
Schek, A. (2018b). *Top ernährt im Sport.* Norderstedt: BoD.
Simopoulos, A. P. (2007) Omega-3 fatty acids and athletics. *Curr. Sports Med. Rep., 6* (4), 230-236.
Spriet, L. L. (2014). New insights into the interaction of carbohydrate and fat metabolism during exercise. *Sports Med, 44* (Suppl. 1), 87S-96S.
Starling, R. D., Trappe, P. A., Parcell, A. C. et al. (1997). Effects of diet on muscle triglyceride and endurance performance. *J. Appl. Physiol., 82* (4), 1185-1189.

Stellingwerff, T., Spriet, L. L., Watt, M. J. et al. (2006). Decreased PDH activation and glycogenesis during exercise following fat adaptation with carbohydrate restoration. *Am. J. Physiol., 290* (2), E380-388.

Stephens, F. B., Constantin-Teodosiu, D. & Greenhaff, P. L. (2007). New insights concerning the role of carnitine in the regulation of fuel metabolism in skeletal muscle. *J. Physiol., 581* (Pt 2), 431-344.

Stephens, F. B., Wall, B. T., Marimuthu, K. et al. (2013). Skeletal muscle carnitine loading increases energy expenditure, modulates fuel metabolism gene networks and prevents body fat accumulation in humans. *J. Physiol., 591* (18), 4655-4666.

Thomas, D. T., Erdmann, K. A. & Burke, L. M. (2016). American College of Sports Medicine joint position statement: Nutrition and athletic performance. *Med. Sci. Sports Exerc., 48* (3), 543-568.

US-Department of Agriculture (2014). *National Nutrient Database. 04047, Oil, coconut* (https://ndb.nal.usda.gov/ndb/).

Van Loon, L. J. C. (2004). Use of intramuscular triacylglycerol as a substrate source during exercise in humans. *J. Appl. Physiol., 97* (4), 1170-1187.

Van Thuyne, W. & Delbeke, F. T. (2006). Distribution of caffeine levels in urine in different sports in relation to doping control before and after the removal of caffeine from the WADA doping list. *Int. J. Sports Med., 27* (9), 745-750.

Van Zyl, C. G., Lambert, E. V., Hawley, J. A. et al. (1996). Effects of medium-chain triglyceride ingestion on carbohydrate metabolism and cycling performance. *J. Appl. Physiol., 80* (6), 2217-2225.

Vistisen, B., Nybo, L., Xu, X. et al. (2003). Minor amounts of medium-chain triglyceride ingestion on carbohydrate metabolism and cycling performance. *J. Appl. Physiol., 95* (6), 2434-2443.

Vogt, S., Heinrich, L., Schumacher, Y. O. et al. (2005). Energy intake and energy expenditure of elite cyclists during preseason training. *Int. J. Sports Med., 26* (8), 701-706.

Vogt, M., Puntschart, A., Howald, H. et al. (2003). Effects of dietary fat on muscle substrates, metabolism, and performance in athletes. *Med. Sci. Sports Exerc., 35* (6), 952-960.

Volek, J. S., Noakes, T. & Phinney, S. D. (2015). Rethinking fat as a fuel for endurance exercise. *Eur. J. Sport Sci., 15* (1), 13-20.

Wall, B. T., Stephens, F. B., Constantin-Teodosiu, D. et al. (2011). Chronic oral ingestion of L-carnitine and carbohydrate increases muscle carnitine content and alters muscle fuel metabolism during exercise in humans. *J. Physiol., 589* (Pt 4), 963-973.

Wardenaar, F., Brinkmans, N., Ceelen, I. et al. (2017). Macronutrient intakes in 553 Dutch elite and sub-elite endurance, team, and strength athletes: Does intake differ between sport disciplines? *Nutrients, 9* (2): 119 (doi: 10.3390/nu9020119).

Wee, S. L., Williams, C. & Garcia-Roves, P. (1999). Carbohydrate availability determines endurance running capacity in fasted subjects. *Med. Sci. Sports Exerc., 31* (5), Suppl. (abstract 299), S91. Download unter https://journals.lww.com/acsm-msse/Fulltext/1999/05001/CARBOHYDRATE_AVAILABILITY_DETERMINES_ENDURANCE.299.aspx.

Whitley, H. A., Humphreys, S. M., Campbell, I. T. et al. (1998). Metabolic and performance responses during endurance exercise after high-fat and high-carbohydrate meals. *J. Appl. Physiol., 85* (2), 418-424.

Yeo, W. K., Carey, A. L., Burke, L. M. et al. (2011). Fat adaptation in well-trained athletes: effects on cell metabolism. *Appl. Physiol. Nutr. Metab., 36* (1), 12-22.

Zajac, A., Poprzecki, S., Maszczyk, A. et al. (2014). The effects of a ketogenic diet on exercise metabolism and physical performance in off-road cyclists. *Nutrients, 6* (7), 2493-2508.

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