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Nutritional Recommendations for Divers

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Competitive diving involves grace, power, balance, and flexibility, which all require satisfying daily energy and nutrient needs. Divers are short, well-muscled, and lean, giving them a distinct biomechanical advantage. Although little diving-specific nutrition research on performance and health outcomes exists, there is concern that divers are excessively focused on body weight and composition, which may result in reduced dietary intake to achieve desired physique goals. This will result in low energy availability, which may have a negative impact on their power-to-weight ratio and health risks. Evidence is increasing that restrictive dietary practices leading to low energy availability also result in micronutrient deficiencies, premature fatigue, frequent injuries, and poor athletic performance. On the basis of daily training demands, estimated energy requirements for male and female divers are 3,500 kcal and 2,650 kcal, respectively. Divers should consume a diet that provides 3–8 g/kg/day of carbohydrate, with the higher values accommodating growth and development. Total daily protein intake (1.2–1.7 g/kg) should be spread evenly throughout the day in 20 to 30 g amounts and timed appropriately after training sessions. Divers should consume nutrient-dense foods and fluids and, with medical supervision, certain dietary supplements (i.e., calcium and iron) may be advisable. Although sweat loss during indoor training is relatively low, divers should follow appropriate fluid-intake strategies to accommodate anticipated sweat losses in hot and humid outdoor settings. A multidisciplinary sports medicine team should be integral to the daily training environment, and suitable foods and fluids should be made available during prolonged practices and competitions.

Keywords: swimming, diving, nutrition, aesthetic sport, energy balance

History of Diving

Men's diving was first introduced as an Olympic sport in the 1904 St. Louis Olympic Games, with women's diving added in the 1912 Stockholm Olympic Games. Diving has been continuously included in the summer Olympic Games since that time. The 1908 Olympics in London included a full competition in "fancy diving" from both platform and "elastic board." Women's "plain diving," without acrobatic feats, was added in the 1912 Olympics, and springboard was added in 1920 (Baird, 1994). Founded in 1908, the Fédération Internationale de Natation (FINA), the international aquatic sports federation, now governs all five aquatic sports, including diving.

Since the first FINA Diving World Championships in 1973, the number of international senior diving competitions has steadily increased to a year-round diving circuit. Currently, FINA is responsible for supervising the World Aquatic Championships, the Diving World Cup, the Diving World Series, and the Diving Grand Prix and the Olympic Games diving events. There are additional diving events at club, regional, national, and continental levels. At the FINA World Aquatic Championships, two events are contested that are not in the Olympics, including 1-m diving (since 1991) and high diving (since 2013), consisting of 27 m for men and 20 m for women (Heller, 2013). Since the 1980s, there has been, in addition to the senior circuit, an increasingly available year-round program of international diving competitions for juniors (age groups 13–18) and for masters (age groups ranging from 25 and older to 90 and older). Top-level junior divers may be entered into senior competition in the year in which they reach age 14 (FINA, 2009–2013).

Diving at the Olympic Games

The Olympic diving events currently consist of four events for men and four events for women, with four synchronized diving events being added to the summer

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Olympic games in Sydney, New South Wales, Australia, in 2000 (see Table 1).

The springboard and platform diving events require competitors to complete five different dive types—forward, back, reverse, inward, and twisting. Male springboard divers have one more dive than female divers and, therefore, repeat one of the dive categories for their sixth dive. The platform diving event includes all five types of dives included in the springboard event, with a sixth category, the arm stand, which may combine somersaults and twists. In the individual events, divers compete with optional dives only, which emphasize acrobatic skills. In the synchronized diving events, the first two dives of each pair are relatively easy, with a prescribed degree of difficulty of 2.0. Points for the judges to consider include the technique and grace of the starting position, the approach, the takeoff, the flight, and the entry (FINA, 2009–2013). The degree of difficulty of the dives performed and the degree of performance perfection are rising with every Olympic Games (Geissbühler, 2012). This may be attributed to increased training time, better talent identification (Zimmermann, 2009), improved sport-specific conditioning (McNeal, 2013), and closer cooperation between diving coaches and scientists (Naundorf et al., 2006). The ever-increasing difficulty of dives has increased physical and mental demands, forcing divers and their coaches to explore new and novel strategies, including nutrition, that have the potential of ethically enhancing performance.

Components of Diving Training Programs

Although an aquatic sport, diving closely mirrors the skills set of gymnastics and acrobatics, with training focusing heavily on tumbling and water entry (Table 2**).** Diving coaches supervise many training activities, and strength and conditioning and other specialty coaches direct other activities. National teams often train and live in centralized training environments that include a swimming pool, dry-land fitness area, and supporting sports science and medicine facilities.

A typical training day for competitive divers consists of two training sessions, with both sessions involving 1 hr of dry-land training, followed by 1.5 hr of diving in the pool (Minganti et al., 2011). Springboard divers average 100–150 dives per day, and platform divers average 50–100 dives per day. During dry-land training, 50–100 somersaults are practiced as part of various tumbling skills, with full-time training typically running to 40 hr per week. Young aspiring international-level divers often have six to nine diving training sessions per week by age 12 (Foley et al., 2005). The International Olympic Committee consensus statement on training the elite child athlete emphasizes that training programs for children should be age appropriate, pleasurable, and fulfilling (Mountjoy et al., 2008). There is concern, however, that these guidelines are not universally followed within diving (Zimmermann, 2013). Competitive diving often begins during the prepubertal years because 14-year-old divers may compete at senior international-level events, including the Olympic Games. There have been warnings from experienced researchers that accelerated training diving programs during adolescence may result in higher rates of physical and psychological injury (Raspopova, 2005).

Physical Characteristics of Divers

Data on the physical characteristics of male and female divers for the London 2012 Olympic Games were published in *The Guardian* (Rogers, 2012). These data indicate that the median age for divers was 22 years and 23 years for male and female divers, respectively (Table 3). The median reported heights were 172 cm (67.7 in.) and 160 cm (64.0 in.) for male and female divers, respectively; and the median reported weights were 67 kg (147.4 lb) and 53 kg (116.6 lb) for male and female divers, respectively. Researchers investigating the physical characteristics of elite divers ($N = 82$) competing in the 1991 FINA World Aquatic Championships reported similar values (Carter & Ackland, 1998). Male divers were taller and heavier and had lower skinfold measurements than

Table 1 Current Olympic Diving Events

Men
10-m platform
3-m springboard
synchronized 10-m platform
synchronized 3-m springboard
Women
10-m platform
3-m springboard
synchronized 10-m platform
synchronized 3-m springboard

Table 2 Components of Diving Training

Supervised by the Diving Coach		
Pool training	**Dry-land area training**	**Team meetings**
basic diving skills	conditioning, body weight	goal setting
line-ups	conditioning, free weights	goal evaluation
jumps	tumbling on the floor	video replay
preparatory dives	tumbling on mini-trampoline	imagery training
competition dives	trampoline	parent meetings
	dry-land board	public appearances
	overhead mounted belt	
Supervised by Other Coaches		
tumbling	gymnastics coach	
dance	dance teacher	
ballet	ballet teacher	
weights	strength and conditioning coach	
plyometrics	track and field coach	
running	track and field coach	
Other Professionals for Periodic Consultation		
primary care sports medicine physician		
sport physical therapist		
sport psychologist		
sport psychiatrist		
sport nutritionist		
sport biomechanic or scientist		
media coach or communication coach		
manager or commercial advisor		

Table 3 Age, Height, and Weight of Olympic Divers Competing in the 2012 London Olympic Games

Characteristic	Men	Women
Age (years)		
Median	22	23
Youngest	16	14
Oldest	32.	33
Lower quartile	20	20
Upper quartile	26	26
Height (cm [in.])		
median	172 (67.7)	160 (62.9)
shortest	155 (61.0)	147 (57.9)
tallest	183 (72.0)	170 (66.9)
lower quartile	166 (65.4)	157 (61.8)
upper quartile	175 (68.9)	164 (64.6)
weight (kg [lb])		
median	67 (147.4)	53 (116.6)
lowest	42 (92.4)	36 (79.2)
highest	79 (173.8)	64 (140.8)
lower	62 (124.0)	50 (110.0)
upper	72 (158.4)	59 (129.8)

Note. From Rogers (2012).

female divers (Carter & Ackland, 1998). In comparison with generally active children, elite adolescent divers are typically shorter, lighter, and more heavily muscled and have broader shoulders and narrower hips (Sovak et al., 1992). A small, well-muscled physique coupled with high explosive power and good flexibility are characteristics that have distinct biomechanical advantages in diving.

Nutrition Issues in Divers

Pressure is placed on divers to achieve, through manipulation of weight and body composition, a physique that is consistent with competitive expectations. Consequently, divers may resort to energy restriction to achieve the desired physical characteristics. This emphasis on weight, performance, and appearance is engrained from a young age as athletes strive to attain a high lean-to-fat ratio, with the goal of achieving a highly toned and contoured physique. Although this body type is desirable for almost every sport, the ideal physique for diving is more difficult to maintain after puberty (Sundgot-Borgen & Torstveit, 2010). Consequently, after puberty some divers find more difficult dives impossible to perform even though they were capable of performing these dives when they were younger with smaller physiques (Raspopova et al., 2005). This psychological pressure to stay small lingers with aesthetic sport athletes, including divers, from the beginning through to the elite-level stages of training.

Dietary restriction may form the prominent strategy for reducing energy availability to modify body size, weight, and composition (Loucks et al., 2011). A failure to adequately satisfy energy requirements has health and performance implications for divers: Low energy availability is associated with impaired immunocompetence (Nova et al., 2001); dizziness, weakness, and shortness of breath (Ersoy, 1991); higher body fat percentages (Deutz et al., 2000); increased risk of low bone density (Deutz et al., 2000); greater risk of amenorrhea (Loucks et al., 2011); and lower resting metabolic rate (Loucks, 2003; Sundgot-Borgen, 1994). It is notable that rhythmic gymnasts, who may restrict energy consumption more than artistic gymnasts, have higher body fat percentages than artistic gymnasts at comparable ages (Deutz et al. 2000). As with other aesthetic sports, the hours young competitive divers spend on training is extremely high. Coupled with increased energy and nutrient requirements to support growth and development, young divers may be at high risk of nutritional inadequacy.

As documented in wrestlers and artistic gymnasts, restrained eating by younger divers may result in a failure to achieve the predicted adult height (Georgopoulos et al., 2010). Athletes with training schedules that exceed 18 hr/week before and during puberty have marked stunting of growth, which could permanently affect achievement of predicted adult height (Theintz et al., 1993). The reduced growth may be due to a diet-related inhibition of the hypothalamic–pituitary–gonadal axis from inadequate energy and nutrient intake or from the combination of inadequate energy and nutrients coupled with a heavy training regimen (Lindholm et al., 1994). Heavy training may have an impact on the anabolic-to-catabolic (insulin-like growth factor 1-to-cortisol) ratio, indicating a catabolic state from energy intake inadequacy (Daly et al., 1998). Studies of gymnasts have found that a delay in achieving each stage of pubertal development was closely associated with the amount of energy expended, with more advanced gymnasts (i.e., those with greater training times and greater energy expenditures) having lower height velocity curves (Theodoropoulou et al., 2005). There is also concern that restrained eating may increase the risk of eventually developing eating disorders, with associated amenorrhea and low bone mineral density (Barr et al. 1994).

Diving-specific training and competition are primarily anaerobic with a high reliance on phosphocreatine and glycogen. During preparatory phases after an annual break or injury, general nonspecific conditioning work may be included in daily training. Lower intensity conditioning or cross-training work is regularly included, which may further stress muscle glycogen stores, particularly in athletes following a restricted dietary intake. The recommendations of major nutrition and sports medicine organizations provide a general framework to which sports nutrition practitioners can refer when consulting with athletes (Rodriguez et al., 2009). These recommendations are useful for avoiding a mismatch between sport and growth-related energy and nutrient requirements and the consumption of energy and nutrients.

Energy and Nutrient Intakes

Although the data on energy and nutrient intakes of divers are limited, the eating behavior of divers is believed to be similar to that of athletes in other aesthetic sports, including figure skating and gymnastics, in which appearance is viewed as an integral component of high-level performance. In a combined study reporting dietary intakes of collegiate swimmers (n = 18) and divers (n = 6), mean reported energy intake (± standard deviation) was 10,061 ± 3,617 kJ/day (2,405 ± 864 kcal/day), with carbohydrate and protein intakes of 5.7 g/kg and 1.2 g/kg, respectively (Petersen et al., 2006). A study investigating dietary intake and eating patterns of Olympic athletes reported that athletes in weight-important sports (including four divers) consumed less energy than athletes in other groups (Burke et al., 2003). Furthermore, athletes in weight-aesthetic sports had fewer occasions to eat during the day than other athlete groups (Burke et al., 2003).

Using the median heights and weights of the divers competing at the London Olympic games and typical exercise intensities at practices and competitions, we predicted energy requirements for male and female divers. For this procedure, we used the Harris-Benedict equation to predict resting energy expenditure and a metabolic equivalent value table (Food and Nutrition Board, 1989) to predict the energy requirement of specific exercise intensities. The estimated energy requirement for male divers during a typical practice day was 3,500 kcal; for female divers, the estimated requirement was

Table 4 Predicted Energy Requirements for Male and Female Divers During Practice and Competition

Diver	Weight (kg [lb])	Height (cm [in.])	Predicted kcal Required	Predicted KJ Required
Competition				
male	67 (147.4)	172 (68)	3,200	13,389
female	53 (116.6)	160 (63)	2,400	10,042
Practice				
male	67 (147.4)	172 (68)	3,500	14,644
female	53 (116.6)	160 (63)	2,650	11,088

Note. Resting energy expenditure predicted using Harris-Benedict equations, and total energy requirements predicted from metabolic equivalent values derived from Food and Nutrition Board, Recommended Dietary Allowances, Table 3.2. Calculations are based on hourly predicted exercise intensities. Male and female weights and heights represent the medians for divers competing at the 2012 London Olympic Games

2,650 kcal. As expected, estimated energy requirements during a competition day were lower for male (3,200 kcal) and female (2,400 kcal) divers because of a decrease in overall exercise on those days.

Although energy requirements are reduced during competition, divers need to maintain an adequate intake of fuel foods on these days. It typically takes 1 min to complete the procedure for a single competition dive, so in a preliminary competition with 40 contestants each diver must wait 40 min between dives. The duration of a typical competition suggests that it is important for divers to develop food and fluid strategies for sustaining normal blood sugar and energy status.

Energy Substrate Intakes

Carbohydrate. New information has changed the understanding of the needs of athletes and the advice provided to them regarding their daily training carbohydrate intake and competition carbohydrate strategies (Burke et al., 2011). Interpretation of these guidelines with respect to an athlete's dietary plan should consider the diver's total daily energy requirements, specific training volume and intensity, gender, environmental conditions, and requirements for growth and development (for children and adolescent athletes; Rodriguez et al., 2009). Although divers typically train for at least 5 hr each day, an inherent knowledge of the training and competition demands is essential to interpret current carbohydrate intake guidelines. Although we have no definitive assessment of carbohydrate usage during diving training, it is likely that daily requirements are within 3–8 g/kg body mass/day, with the higher values accommodating growth and development in younger divers. Divers should avoid carbohydrate-loading strategies that maximize glycogen stores because they could compromise flexibility (Maughan & Poole, 1981). With the exception of during-exercise carbohydrate consumption and carbohydrate immediately after exercise, nutrient-dense carbohydrates rather than low nutrient-density carbohydrates (i.e., refined sugary foods and fluids) are preferred (Benardot, 2007).

Protein. Total daily protein intake to optimize the adaptation from daily training and promote recovery after exercise is approximately 1.2–1.7 g/kg body mass, depending on protein quality and eating frequency (Phillips & Van Loon, 2011; Rodriguez et al., 2009). The timing of protein intake is as crucial as the amount consumed. Recommended protein intake can generally be met through diet alone, although the use of protein drinks (i.e., whey protein isolate) and related packaged foods may assist in the timely intake of protein immediately after training or competition. Slightly higher protein intake may be required for athletes striving to lose (fat) weight so as to better maintain lean muscle mass (Mettler et al., 2010). Adequate energy intake sufficient to maintain body weight is necessary for optimal protein use and performance (Rodriguez et al., 2009). Ideally, the diver should maintain energy balance and a regular meal pattern, providing 20–30 g/meal of high-quality protein to maintain or increase muscle mass and bone density and to satisfy creatine synthesis (Koenig et al., 2008; Paddon-Jones & Rasmussen, 2009). The consumption of a carbohydrate- and protein-rich snack immediately after exercise is also useful for reducing exercise-associated muscle soreness, improving postexercise muscle recovery, and enhancing muscle protein synthesis (Koopman et al., 2007; Moore et al., 2010; Tang et al., 2009).

Fat. Fat is a source of energy, fat-soluble vitamins, and essential fatty acids. Although high-fat diets are not recommended for athletes, they should be consumed at a level of 20%–25% of total energy intake to help ensure that total energy requirements are met (Rodriguez et al., 2009).

Micronutrient Intakes

To ensure sufficient intake of micronutrients (i.e., vitamins and minerals), divers are encouraged to consume nutrient-dense foods (International Olympic Committee Consensus Statement on Sports Nutrition, 2010). Divers who restrict energy intake or use severe weight-loss practices; eliminate one or more food groups from their diet; or consume high- or low- carbohydrate diets of low micronutrient density are at greatest risk of micronutrient deficiencies. Divers should strive to consume diets that provide at least the Dietary Reference Intakes for all micronutrients (Rodriguez et al., 2009).

Studies assessing the diets of adolescent female aesthetic sport athletes have suggested that they are at high risk of consuming inadequate amounts of macro- and micronutrients in an attempt to achieve or maintain the ideal body size and thinness that is perceived to be associated with success (Ziegler et al., 2005). This inadequate nutrient intake may be influenced by negative environmental factors, such as a demanding training schedule, lack of time to consume nourishing meals, and increased emphasis on physical features, such as leanness and body image (Ziegler et al., 2002). Prolonged energy restriction combined with inadequate micronutrient intake can result in amenorrhea, eating disorders, osteoporosis, injuries, and delayed growth (Ziegler et al., 2005). In an interview with two elite male divers (D. Benardot, personal communication, September 2013), it was apparent that they binge-consumed alcohol and had high caffeine intakes. Neither male diver felt pressure to restrict food intake. However, they felt that many female divers were excessively weight conscious and consistently restricted food intake. These statements from divers are consistent with studies of athletes in other sports, suggesting that female divers are at greater risk for inadequate micronutrient intakes than male divers because of restrained eating patterns.

Athletes should rely on food rather than vitamin and mineral supplements for obtaining needed nutrients but, with proper medical supervision, the intake of certain mineral supplements (calcium and iron in particular) may be advisable. Vegetarianism may increase nutrient risks for iron, zinc, and calcium, but proper dietary planning can overcome these challenges. It is recommended that vegetarian athletes consult with a qualified sports nutrition professional to avoid these nutrition concerns (Rodriguez et al., 2009).

Iron. A study assessing iron status of collegiate swimmers and divers reported a median serum ferritin of 12.7 µg/L (range = 1.6–113.5 µg/L), suggesting a marginal iron status (Petersen et al., 2006). Athletes in similar aesthetic sports have reported inadequate dietary iron intake below the recommended level (15 mg/day in female athletes between ages 11 and 24 years), which has implications for resistance to disease, growth, strength, and ability to concentrate (Loosli, 1993). It is estimated that the typical diet in industrialized nations provides about 6 mg of iron per 4.2 MJ (1,000 kcal) of energy. This food concentration level of iron would require that divers have an average minimum energy consumption of approximately 2,500 kcal/day to satisfy the dietary intake of iron.

Calcium. No calcium studies have been done on divers, but a low intake of calcium, coupled with low vitamin D exposure or intake, has been found to predispose athletes to stress fractures (Lovell, 2008). Adequate calcium intake (1,000–1,500 mg/day) may impart some degree of safety in helping to reduce stress fracture risk, and if it is not possible to obtain sufficient calcium through food consumption, calcium supplementation has been effective in increasing bone mineral density in children (Johnston et al., 1992).

Vitamin D. Vitamin D is known to promote the mineralization of bones and teeth by enhancing calcium and phosphorus absorption, but vitamin D also has multiple other functions that influence the athletic endeavor. These functions include enhancing muscle contraction, muscle protein anabolism, improved immune function, and enhanced anti-inflammatory action (Cannell et al., 2009; Hamilton, 2010; Schubert & DeLuca, 2010; Williams, 2004). A significant proportion of athletes training indoors have below-optimal levels of serum vitamin D (Lovell, 2008). However, a study investigating vitamin D status and supplementation in collegiate swimmers and divers training indoors found a relatively low prevalence of vitamin D insufficiency (25-hydroxy vitamin D < 32 ng/ml) and an absence of vitamin D deficiency (25-hydroxy vitamin D < 20 ng/ml; Lewis et al., 2013).

Vitamin and Mineral Supplementation and Ergogenic Aids

Athletes may consume high-dose dietary supplements as part of their regular training or competition routine (Maughan et al., 2007). Although heavy training is associated with depressed immune cell function, there is no evidence that high doses of "immune-boosting" supplements, including antioxidant vitamins, prevent exercise-induced immune impairment (Gleeson et al., 2004; Nieman, 2007). Some dietary supplements that appear legitimate are contaminated with undeclared substances prohibited by the World Anti-Doping Agency (Maughan, 2005; Maughan et al., 2007). As a result of these findings, divers should pursue a "food-first" approach to obtaining required nutrients and carefully consider the potential problems of taking supplements when there is no diagnosed reason to take them.

Fluid and Hydration Strategies

Divers should consume sufficient fluids before, during, and after exercise to sustain health and performance. Dehydration, defined as a body water deficit in excess of 2%–3% body mass, decreases exercise performance in laboratory settings. During exercise, divers should consume sufficient fluids to avoid a more than 2% body mass loss. It is also advisable for athletes to avoid consuming fluids in excess of their sweat rate, which could predispose them to hyponatremia. In addition, a small amount of carbohydrate (~6% solution) in the hydration fluid may serve to sustain normal blood sugar. After exercise, it is recommended that approximately 16–24 oz. (450–675 mL) of fluid for every pound (0.5 kg) of body weight lost during exercise be consumed (Rodriguez et al., 2009). Recovery rehydration beverages should replace water and sodium losses (International Olympic Committee Consensus Statement on Sports Nutrition, 2010). Data from Olympic divers during training in an indoor pool indicated an average sweat rate of 0.22 (*SD* = 0.3 L/hr; Ranchordas & Rogerson, 2013). This study reported a tendency for divers to overhydrate. A 145-min training session consisting of 65 min of training on dry land and 80 min of training in the pool resulted in divers losing an average of 0.52 L of fluid but ingesting 0.60 L of fluids.

Nutritional Strategies for Competition and Training

A multidisciplinary sports medicine support team should be engaged within the daily training environment and competition arena to ensure nutrition-related issues are managed appropriately. Table 5 outlines key members

Table 5 Roles of Sports Medicine Team Members to Support Health and Performance for Divers

Professional	Role
Physiotherapist or physical therapist	• Annual musculoskeletal screening with follow-up • Regular communication with soft tissue therapist to keep updated on any potential injury concerns • Direct communication with sport physician and coach regarding injury status and management • Direct communication with strength and conditioning coach to devise return to sport rehabilitation and maintenance programs
Soft tissue therapist	• Provision of regular soft tissue support to athletes, preferably on a weekly basis • Regular communication with physiotherapist on areas of concern for early identification of potential injuries
Sport dietitian	• Periodic dietary intake and anthropometric screening with follow-up • Individual dietary counseling to assist daily training performance, recovery, and body composition management • Direct communication with sport physician for management of iron status and bone health • Regular communication with coach, sport psychologist, and sport physician regarding body image concerns
Sports physician	• Annual medical screen including relevant pathology for divers including iron and vitamin D status with follow-up • Primary care provider at the first sign of injury or illness • Direct communication with the coach to assist in the management of training loads on the onset and return to training after injury and illness • Regular communication with the physiotherapist to manage return to training after injury • Regular communication with the sport dietitian and psychologist regarding athlete health and well-being • Menstrual history (female divers)
Sport psychologist and sport psychiatrist	• Annual psychology screening with follow-up • Individual psychological counseling and intervention strategies to assist competition performance • Management of psychological stresses that relate to daily sport and lifestyle and communication with coach • Regular communication with coach, sport dietitian, and sports physician regarding body image concerns
Strength and conditioning coach	• Regular strength and power assessments of athletes • Coordinated approach with physiotherapist regarding return to sport after injury • Direct communication with coach and physiotherapist to develop physical qualities of the athletes

of a multidisciplinary support team and their nutrition-related roles.

Precompetition and Training

The goal of the precompetition or training meal is to promote carbohydrate availability and ensure the diver is well hydrated at the onset of exercise. Before training or competition, a meal or snack scheduled 1–4 hr before exercise should provide adequate fluid, be relatively low in fat and fiber to facilitate gastric emptying and minimize gastrointestinal distress, contain carbohydrate, be moderate in protein, be composed of familiar foods, and be well tolerated by the athlete (Rodriguez et al., 2009). Because blood sugar fluxes in 3-hr units, the precompetition or training meal should be followed with foods and beverages that can sustain normal blood sugar when the competition or practice is more than 3 hr later than the meal (Benardot, 2007; Deutz et al., 2000). During a precompetition taper period and during prolonged competitions such as the Olympic Games, divers reduce the number of dives and the intensity of dry-land training. Their food intake must be adjusted accordingly.

During Competition and Training

Exercise demands for dry-land and pool diving sessions far exceed those of diving competition. Hence, nutritional support should be adjusted to reflect this obvious difference in energy requirements. Diving training is explosive and intermittent, requiring athletes to complete high repetition of dives or related skills. As such, divers should be encouraged to consume small amounts of carbohydrate during training and competition to maintain blood sugar levels and promote carbohydrate availability (Burke et al., 2011). Athletes are reminded to drink to minimize weight loss to less than 2% body weight, particularly in outdoor or humid indoor facilities (Rodriguez et al., 2009).

Postcompetition and Training

The primary postexercise dietary goals are to provide adequate fluids, electrolytes, energy, carbohydrates, and protein to recover muscle glycogen and fluid stores as well as facilitate maximal protein synthesis. General recommendations are to consume a carbohydrate intake of approximately 1.0–1.5 g/kg body mass (0.5–0.7 g/lb) during the first 30 min and again every 2 hr for 4–6 hr to replace glycogen stores (Rodriguez et al., 2009). Given the nature of daily training sessions and the importance of maintaining a lean physique, these recommendations should be adapted to the needs of individual divers. The posttraining or competition intake should be planned to reduce time between the end of exercise and the availability of food and beverages. Alcohol consumption should be avoided because it interferes with optimal performance on subsequent days (Shirreffs & Maughan, 2006). Although the prevalence of alcohol consumption in divers has not been assessed, studies of athletes in other sports suggest its use is widespread (Yusko et al., 2008).

Travel Considerations

Competitive divers inevitably find themselves competing away from home, often in locations with unfamiliar foods and food safety issues. Regardless of the distance traveled, planning ahead is essential to ensure the final performance matches the athlete's trained capabilities. This is particularly important for divers and their support staff when traveling to underdeveloped countries in which the risks of food- or water-borne gastrointestinal infections are highest. Travel and the final precompetition period offer considerable downtime for incidental eating because of boredom. A common mistake athletes make when traveling is to assume their typical dietary choices are available at their new destination. When traveling, preferred foods and fluids should be arranged before departure (Benardot, 2012). Athletes with special dietary needs, allergies, or food sensitivities should have information cards prepared in the local language to avoid misinterpretation.

Relative Energy Deficiency in Sport, Disordered Eating, and Eating Disorders

The spectrum of low energy availability, amenorrhea, and osteoporosis, either alone or in combination, are regarded as significant health risks for female athletes and are medically referred to as *the female triad* or *exercise-induced menstrual dysfunction* (Arasheben et al., 2011). More recently, *relative energy deficiency in sport* has been used in place of the *female athlete triad* to describe a broader range of problems, including greater bone health and eating disorder risks, which occur in both male and female athletes who exercise in an energy-deficient state (Melin et al., 2014). The prevalence of amenorrhea is elevated in women who restrict their diets and who are intensely physically active, including divers (Hecht & Nattiv, 2007). The associated hypoestrogenism causes skeletal demineralization that increases the risk of stress fractures in the near term and of osteoporosis later in life (Loucks et al., 2011). Women who exercise and maintain normal menstrual cycles appear to have higher bone mineral density than amenorrheic women, and low bone mineral density has been reported for adult athletes with amenorrhea (Arasheben et al., 2011). Delayed menarche, menstrual irregularities, and low body fat are frequently seen in aesthetic athletes (Georgopoulos et al., 2001) but, contrary to the commonly held belief that the low body fat is principally responsible for the menstrual dysfunction, it appears that low energy availability is the primary cause (Loucks, 2003). According to Loucks (2003), dysfunction of reproductive hormones occurs below 20–30 kcal/kg lean body mass/day of energy availability (energy consumed minus exercise energy expended in training).

If left untreated, disordered eating can progress to a diagnosis of an eating disorder (American Psychiatric Association 2013), which can result in all of the disordered eating complications. Regardless of the specific eating disorder (i.e., anorexia nervosa, bulimia nervosa, binge eating disorder, and otherwise specified or unspecified), eating disorders should be considered serious conditions (American Psychiatric Association, 2013). See Table 6 for information on how to approach the diver with disordered eating behavior.

Fortes et al. (2013) reported that body dissatisfaction and the commitment to exercise were explanatory risk factors for risky eating behaviors in adolescent aesthetic sport Brazilian athletes, which included divers. Athletes with elevated dietary restraint were found to be as much as 7 times more likely to have musculoskeletal injuries (Rauh et al., 2010).

Summary

Diving is an Olympic sport requiring a combination of explosive power, flexibility, strength, artistry, grace, and courage. There is a paucity of diving-specific nutrition research investigating performance and health-related outcomes. Divers are focused on maximizing the strength-to-weight ratio, which requires an eating strategy that enables a maintenance or increase in muscle mass and a decrease in fat mass. Divers who follow restrained eating patterns with the goal of weight maintenance or loss may develop multiple risk factors that could compromise both nutrition and health status, including the development of eating disorders, as well as athletic performance. There is also evidence that restrained eating is counterproductive in producing the desired body composition. There is a tendency for athletes to focus on the consumption of protein while deemphasizing the importance of carbohydrate and fat. The powerful and anaerobic nature of diving, requiring adequate muscle glycogen and stored phosphocreatine for explosive power, suggests that divers should consume diets that are well balanced in carbohydrate, protein, and fat. Ideally, this consumption should be well timed to avoid an increase in hunger-related cortisol that could compromise bone and muscle mass and should also avoid excessively large meals that may increase the storage of fat. This approach may also help maintain good health and well-being, inevitably extending the career of a diver. Many elite divers are children, who have the combined stresses of growth, development, and the athletic endeavor. Special attention should be given to these young athletes by trained sports medicine professionals to ensure that their nutritional needs are satisfied. Ideally, a multidisciplinary sports medicine team should be available to competitive divers to lower health risks and safely improve diving-specific fitness. Although some evidence has suggested that the daily intake of divers is similar to that of other aesthetic sport athletes, research is needed in this area. Furthermore, there are no studies assessing the degree to which male and female divers satisfy the energy needs of their sport-specific training regimens or competition.

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Table 6 How to Approach the Diver With Disordered Eating Behavior

1. *Direct and empathic approach*—Discuss in a private and quiet place without interruption. Tell the person you are worried about him or her (i.e., if teammates have seen the person vomiting after meals).
2. *Avoid threats of manipulation*—Tell the person her or she has a problem, and it is his or her problem, not your problem. Tell the person that you will help him or her get assistance if he or she needs it. Stand your ground firmly and compassionately.
3. *If the athlete refuses help*—If there are enough reasons to be concerned, a coach or parent should consider removing the athlete from diving until he or she seeks help. This could be a lifesaving intervention.

Note. FINA Aquatic World Magazine—"Aquatic Sports and Diet"—2004

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