Food Pyramids in Sports Nutrition

by Samuel Mettler, PhD and Nanna L. Meyer, PhD, RD, CSSD

Food pyramids are pictorial representations of dietary goals that translate scientific reference data into easily understandable nutrition recommendations. In general, there are two approaches to designing food pyramids. In the nutritive approach, food recommendations are calculated to fulfill dietary reference values for energy, macronutrients, and micronutrients.[1] Consequently, serving sizes for different food groups and corresponding numbers of servings are calculated to meet the energy and nutrient requirements of the target population. Most pictorial food guide systems follow this strategy. In the second approach, the metabolic approach, eating guidelines are linked to the metabolic effect a particular food may exert on physiologic parameters. For example, the low glycemic index pyramid[2] focuses on the effect of food on blood glucose.

Many pyramids today also highlight the quality of food in their pictorial representations (e.g., The Healthy Eating Pyramid[3] and the German three-dimensional Food Guide Pyramid, 2005[4]). Several pyramids from around the world emphasize cultural influences and traditional cuisine,[5] and some of these (e.g., Mediterranean Food Guide Pyramid) have been used in both research and clinical settings for the purpose of health promotion and disease prevention.[6-9]

Comparatively, food guide pyramids do not differ substantially from each other with respect to their food and nutrient recommendations. In fact, Painter and colleagues[5] demonstrated that although food guide systems varied in shapes (e.g., pyramid, wheel, pagoda, rainbow), their basic food group classifications were similar. Only recently have food guide systems included fluids, and only a few have incorporated more novel approaches (e.g., vegetables and fruit as the base before grains; more protein).[10,11] Most pictorial representations include daily physical activity.[12,13]

> "Only recently have food guide systems included fluids."

The majority of food pyramids and other pictorial food guide systems provide a range of serving sizes and/or number of servings per food group[5] to allow individualization for differences in body masses, physical activity levels, and different energy needs. The U.S. Food Guidance System (MyPyramid) provides a range of suggested number of servings for each food group, which is dependent on an individual's energy requirements ranging from 1,600 to 3,000 kcal/day. Consequently, men and women of different ages with three different physical activity levels are

able to identify the suggested number of servings per food group.[14]

General Food Pyramids and the Athlete's Needs

Few pyramids address an athlete's needs. Although the new U.S. Food Guide Pyramid can be used to fit athletes' dietary needs, the recommendations and available worksheets are limited to a total daily energy intake of 3,000 kcal/day, and these guidelines were not developed specifically to address the athlete's energy and nutrient needs.[15] Similarly, Houtkooper[16] modified the standard 1992 U.S. Food Guide Pyramid and included fluids as a new food category at the base of the pyramid, emphasizing the importance of hydration for athletes. The Mediterranean Food Guide Pyramid may be used to accommodate higher energy needs of endurance athletes through increased intake of fat, particularly oils from olives, nuts, and fish.[15] Finally, the Vegetarian Food Guide Pyramid[17] may be adjusted to fit the vegetarian athlete.[18]

When incorporating general food guide pyramids into sports nutrition counseling with athletes and adjusting the number of serving sizes and food group contributions, sports dietitians must have an understanding of how individuals may interpret the messages in these pyramids[13,19-21] so that use of the pyramid assists in meeting energy, nutrient, and fluid needs. Nonetheless, although such pyramids are useful, they will always be limited because they are not intended to address the athlete's energy, nutrient, and fluid needs and timing of ingestion.

One complication that exists in sports nutrition deals with the fact that training programs are periodized with high and low intensity/volume training cycled throughout the annual training and competition plan. A quick guide for adding calories to cover variable training demands using a pyramid format for athletes could assist in successful sports nutrition applications. In light of the complexities and variability of energy, nutrient, and fluid needs of athletes,[22] a simplified pyramid could be extremely helpful, although it would not be without limitations. The Food Pyramid of Swiss Athletes was developed with this concept in mind.

The Food Pyramid for Swiss Athletes

The Food Pyramid for Swiss Athletes (FPSA) represents a quick reference guide for athletes training more than 5 hours per week, providing details on serving sizes for different body masses, number of servings adjusted to number of hours of training per day, and appropriate macronutrient choices to meet the demands of training (Figure 1, page 14). This recently published pyramid[10,23] was developed by the Swiss Forum of Sports Nutrition (www.sfsn.ch), the primary sports nutrition organization in Switzerland. It is important to emphasize that foods and cultures vary globally and no pyramid will suit the needs of all athletes under all circumstances. However, this pyramid can be used to teach several key concepts that are common yet difficult for athletes to integrate successfully into their daily nutrition practices: adjusting energy, nutrient, and fluid needs to changes in training loads (i.e., volume and intensity).

> "...food and cultures vary globally and no pyramid will suit the needs of all athletes."

Nutritional recommendations for athletes, as for other population groups, should primarily promote a well-balanced diet to ensure long-term health. The FPSA is an extension of an existing food guide pyramid for nonathletes: the Food Pyramid for Healthy Swiss Adults of the Swiss Society for Nutrition.[11] The "basic pyramid" layout of FPSA provided the foundation from which energy, nutrient, and fluid needs for the athletes were extrapolated.

The primary aim of the FPSA was to provide a quantitative and qualitative representation of food and fluid needs of athletes of varying body mass and training volume at a fixed moderate intensity (set at 0.1 kcal/kg/min, representing running at 8 km/h, cycling at 2 W/kg, or intermittent exercise of team sports). The secondary aim of the FPSA was to meet the reference values for micronutrients established by the Dietary Reference Intakes (DRIs).[24-29] Thus, the Swiss group used the nutritive approach in its pyramid development.

Development and Validation of the Pyramid

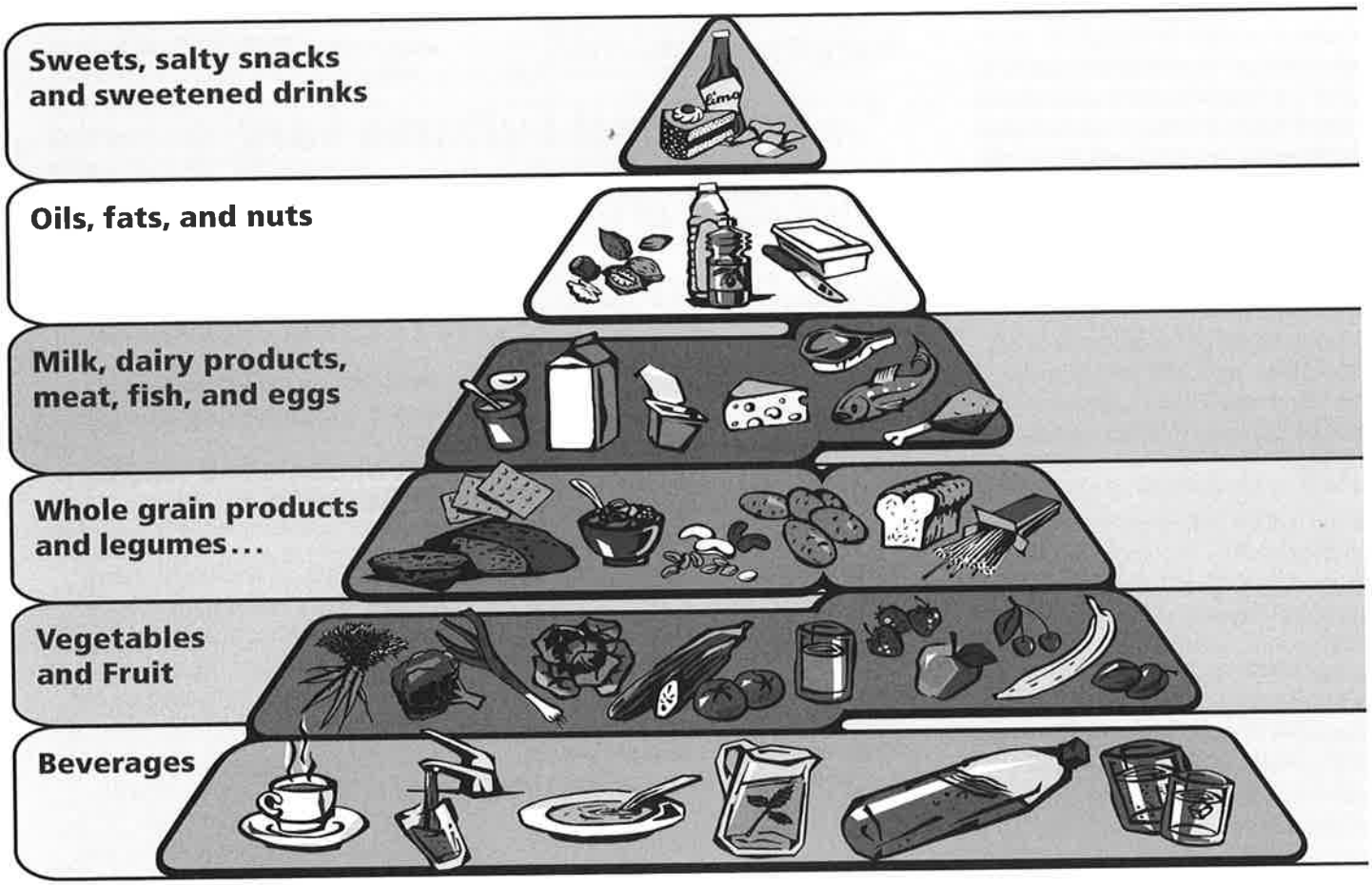
As a first step, an additional energy requirement per kilogram of body mass and per hour of exercise was defined. To calculate the additional energy expended from exercise, the energy need of an average sitting activity was always subtracted, as exercise replaces a sedentary lifestyle rather than being added to it.[10] The additional energy requirement was then distributed as extra servings across the different food groups of the basic pyramid, considering the specific macronutrient recommendations for sports[30,31] and whether the extra servings were feasibly integrated into an athlete's real life. Furthermore, sports foods and fluids (e.g., sports drinks, bars, recovery products) were included as a choice for extra servings next to the food items shown on the basic pyramid. The issue of different energy needs relative to body mass was solved by using variable serving sizes. Consequently, it is the daily exercise duration that determines the number of

Figure 1

Food Pyramid for Athletes

For athletes exercising ≥5 hours per week

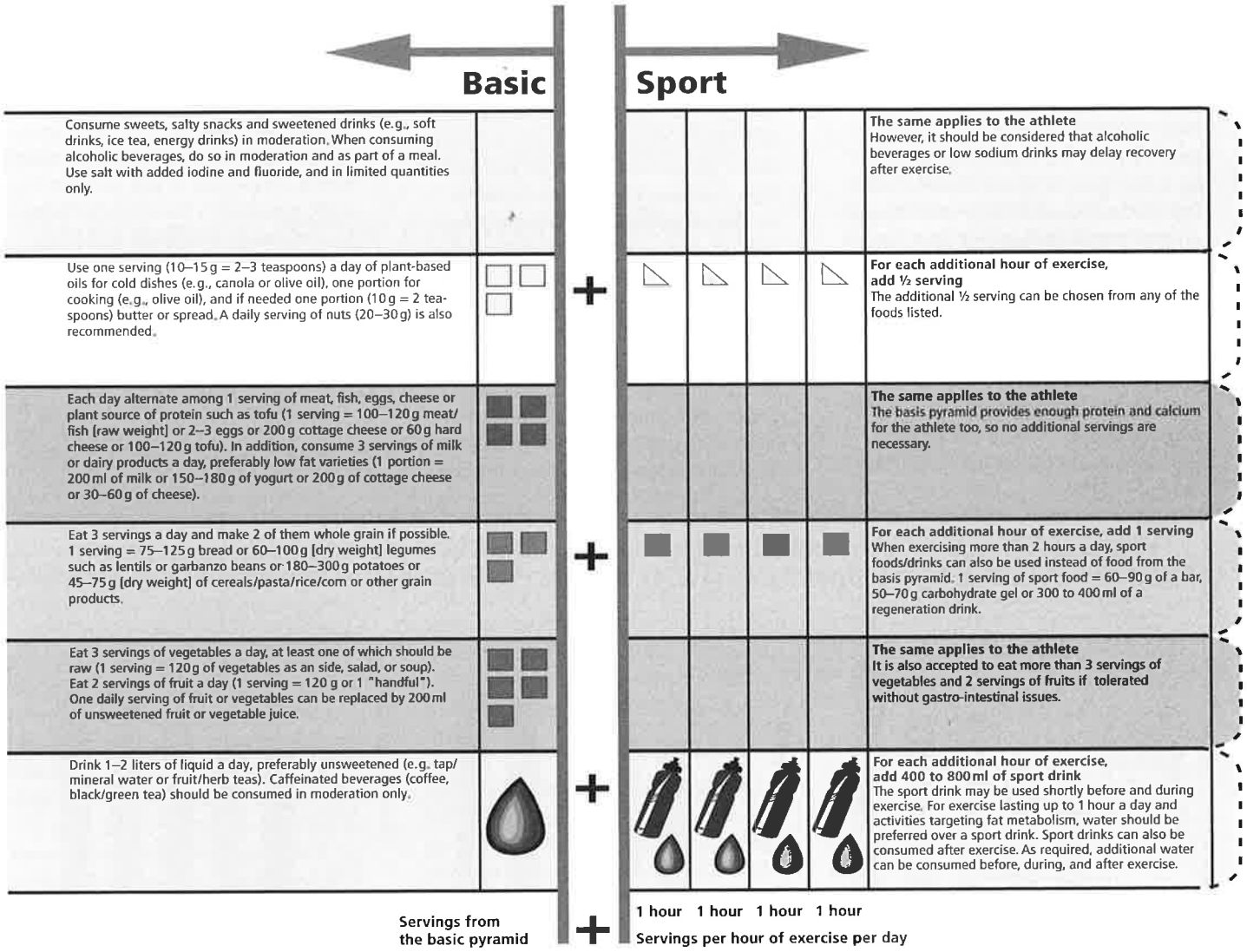
Based on the Food Pyramid for healthy adults of the Swiss Society for Nutrition



The Food Pyramid for Athletes is based on the Food Pyramid designed and developed by the Swiss Society for Nutrition (Schweizerische Gesellschaft für Ernährung) for healthy adults, which will be referred to as the Basic Food Pyramid. This Basic Food Pyramid has been expanded to cover the energy and nutrient needs for daily exercise typically performed by athletes and active individuals.

The Food Pyramid for Athletes is aimed at healthy adults exercising on most days of the week for at least one hour or more per day at moderate intensity, totaling at least 5 hours of exercise per week.

Moderate intensity represents continuous activities such as swimming (2.5 km/h), running (8 km/h) or cycling (2 watts per kg body mass) or the "stop and go" of most intermittent and team sports such as an ice hockey match, a soccer game or tennis match. The Basic Food Pyramid reflects balance in food choice, and the same applies to the recommendations for athletes. Both pyramids ensure sufficient energy and nutrient supply for their target population. All foods are allowed, but it is important that a variety of foods are chosen from each section, that produce is chosen seasonally, and all foods are prepared and processed with care. The regular intake of vitamin and/or mineral



Version 1.2 © 2009 Swiss Forum for Sport Nutrition, www.sfsn.ch, in collaboration with ETH Zurich and Federal Office of Sport FOSPO

fortified foods and beverages or the use of dietary supplements may exceed the upper tolerable intake level for micronutrients.

Adherence to the Food Pyramid for Athletes offers a solid foundation for longterm, successful performance capability. In contrast to the Basic Food Pyramid, where the recommendations do not have to be followed strictly on a daily basis, it is suggested that athletes meet the guidelines consistently to ensure optimal regeneration and performance capability. The additional requirement to cover exercise training includes a volume of 1 to 4 hours of moderate intensity exercise per day. For high intensity exercise and/or greater volumes, the energy and nutrient requirements will be higher. An experienced sports dietitian may help with adjusting food selection and serving size to individual needs.

Serving size selection: From the serving size range given in the pyramid, small athletes of about 50 kg body mass should choose the smallest serving size, whereas the largest serving size applies to athletes weighing about 85 kg. Intermediate serving sizes apply to athletes of corresponding intermediate body mass (e.g. medium serving size for 67.5 kg).

extra servings, whereas the athlete's body mass determines the serving size.[10]

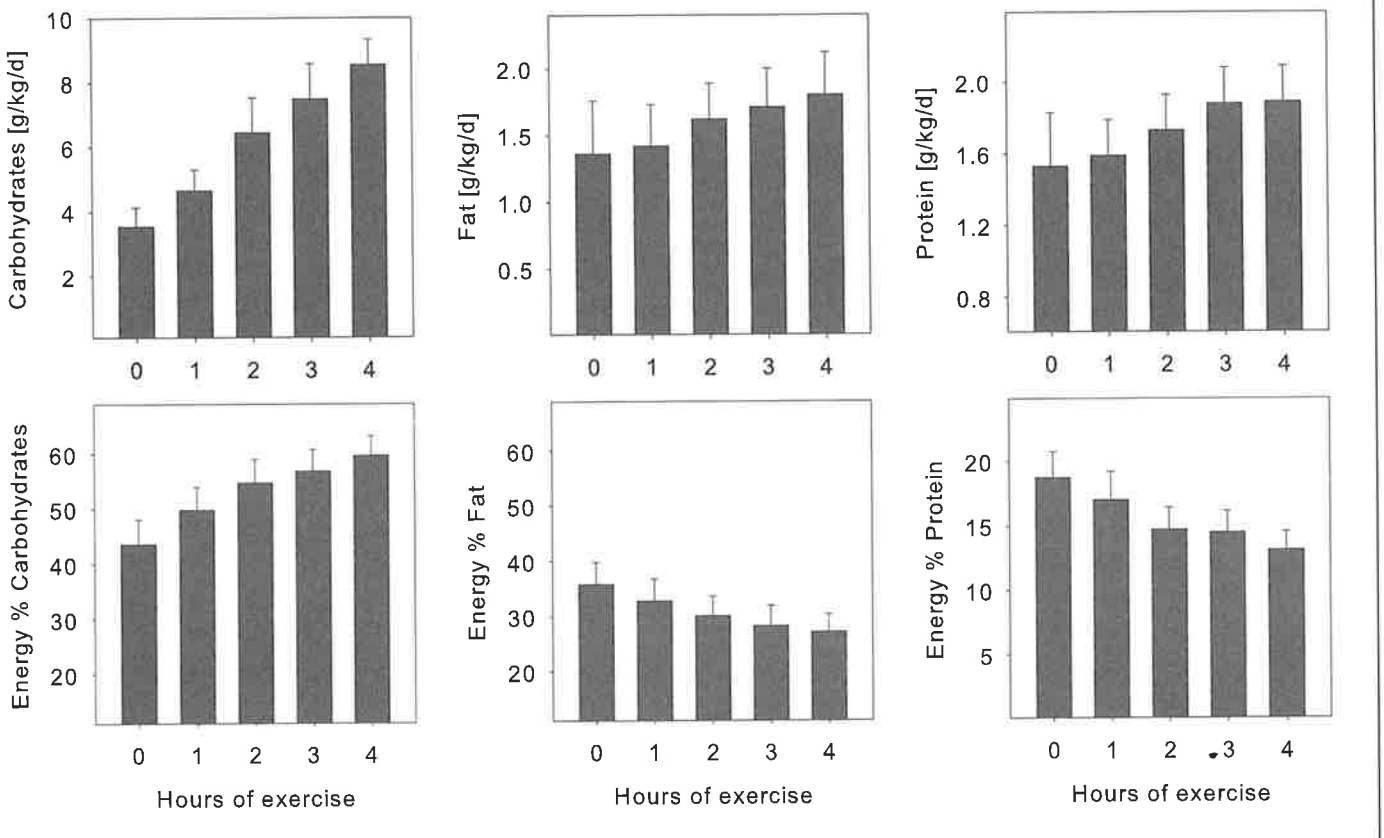
The final version of the FPSA (Figure 1) was validated quantitatively by designing 168 meal plans according to the pyramid's recommendations for athletes with body masses of 50 kg to 85 kg and a daily training volume from 0 (simulating resting days) to 4 hours. The evaluation of the meal plans revealed that energy intake of the meal plans met the calculated energy requirement by 97%.[10] The macronutrient intakes, expressed relative to body mass per day (g/kg/d), by training volume are shown in the top part of Figure 2 (below). The pyramid fulfilled international standards for macronutrient intakes using variable training volumes.[30,31] The micronutrient supply was well beyond the DRIs for nearly all micronutrients.[24-29] Potential critical elements (e.g. iron for women with a low energy budget or vitamin D) and further details about the development and validation of the pyramid are explained in the literature.[10;23]

Application to Practice

In practice, the pyramid may be used in several ways. The pyramid may represent a food guide, and meal plans may be designed according to the pyramid. This application is probably most suitable for sports nutrition education, particularly to illustrate the differences between the energy and nutrient needs for sedentary individuals (or rest days for athletes) and athletes. In addition, the pyramid easily translates carbohydrate guidelines into practice. Athletes often fail to consume sufficient carbohydrates to ensure recovery from repetitive, intense training.[32] The pyramid, at least based on hours trained, can provide a simple tool to put carbohydrate goals into practice. The pyramid also may be used to compare actual eating habits with pyramid guidelines. For example, empty pyramid handouts may be used in a team presentation where athletes are asked to insert their foods and fluids consumed. As more awareness is built around the importance of how to link changes in training volume with changes in food and fluid intakes, the pyramid can serve as a simple yet optimal reference guide. In fact, team presentations can be built on food pyramids and by integrating short workshops, both teaching and learning become more effective.

Professionals and athletes may wonder why the FPSA does not recommend additional servings of protein-rich foods relative to training hours. This is due to the fact that the basic pyramid in Switzerland follows recent trends of slightly increased protein intakes recommended for sedentary individuals for the purpose of weight control.[33] This is also an advantage for athletes, as the protein supply is already conveniently high for athletes with a lower training volume (e.g., power athletes), while not getting too high for athletes with

Figure 2. Average daily macronutrient intake of the 168 meal plans by training volume (mean ± SD) in g/kg/d (upper figures) or as percent (%) of energy intake (bottom figures).



high training volumes (e.g., endurance athletes). The high protein supply at low training volumes may also assist with weight control in nonendurance sports such as gymnastics.[34] With increasing training volumes, more protein is delivered by additional servings from grains as well as sports and recovery foods.

This food pyramid for athletes gives only a general message about sports nutrition, and as with any other guidance system, fine-tuning of individual and sport-specific requirements by a sports dietitian is necessary. Users of the FPSA should consider that the additional servings are calculated for an average, moderate exercise intensity, as defined in the pyramid (see Figure 1). Overfueling and underfueling may occur in low volume (e.g., gymnastics) and high volume sports (e.g., running, cycling), respectively. However, in practice, an athlete exercising at lower intensities simply needs to round the number of servings (e.g., eating for 2 h of exercise according to the pyramid, while exercising for 3 h). Finally, the pyramid is not limited to 4 hours of exercise per day. Further servings may be added for the fifth and sixth hour of training, as indicated by the dotted lines at the right end of the food group layers.

One aspect not directly related to the pyramid but revealed by the validation data, which represent international standards for sports nutrition,[30,31] is the divergent behavior of the macronutrient data expressed either in percent of energy intake (% EI) or relative to body mass (g/kg/d). Figure 2 shows how the supply of macronutrients increases with increasing training volume; however, contributions in % EI only increase for carbohydrate but do not exceed 60% of EI, while % EI for protein and fat decrease. This clearly shows that macronutrient recommendations based on % EI are inappropriate in sports nutrition, as they do not provide any information on the energy and macronutrient supply nor on the corresponding fuel needs of exercising muscles.[30] Macronutrient requirements in sports nutrition should exclusively be calculated in g/kg/day.[30] Whether practitioners communicate these numerical recommendations to athletes depends on individual factors. However, in most cases pyramids, plates, single serving size equivalents (e.g., cups), or other practical tools should be used to translate these quantitative data into easily understandable guidelines.

> "There is no other comparable and as thoroughly validated pictorial food guide for athletes available around the world."

Although this food pyramid for athletes reflects to some degree the cultural foods of Switzerland, the variety of foods modelled within each food group is large and it would be possible to replicate these choices in many countries around the world, particularly Western countries, including the United States and Western Europe, where eating practices are comparable to Switzerland. Furthermore, the amounts of nutrients resulting from the pyramid's recommendation are consistent with internationally accepted DRIs and guidelines.[24-31]

In summary, the FPSA illustrates different energy, macronutrient, and fluid needs of athletes training at variable training volumes in comparison to normally active or sedentary individuals. To date, there is no other comparable and as thoroughly validated pictorial food guide for athletes available around the world.

Samuel Mettler, PhD, is a sports nutritionist at the Swiss Federal Institute of Sport, Magglingen and at the Department of Agricultural and Food Sciences, ETH Zurich, Switzerland. He is also a leading partner of the Swiss Forum for Sports Nutrition, www.sfsn.ch, which is an open access and independent sports nutrition information platform for Switzerland and other German-speaking countries. Nanna Meyer, PhD, RD, CSSD, is an assistant professor at the University of Colorado at Colorado Springs and director of the sport nutrition graduate program. She is also a consultant in sports dietetics at the United States Olympic Training Center in Colorado Springs, CO.

References

1. Stehle P, Oberritter H, Büning-Fesel M, et al. Grafische Umsetzung von Ernährungsrichtlinien - traditionelle und neue Ansätze. *Ern Umsch.* 2005;52:128-135.
2. Ludwig DS. Dietary glycemic index and obesity. *J Nutr.* 2000;130:280S-3S.
3. Harvard School of Public Health. The Healthy Eating Pyramid, Web site. Available at: http://www.hsph.harvard.edu/nutritionsource/what-should-you-eat/pyramid/. Accessed August 18, 2009.
4. Deutsche Gesellschaft für Ernährung. Die Drei-Dimensionale Lebensmittelpyramide, Web site. Available at: http://www.dge.de/modules.php?name=Content&pa=showpage&pid=40. Accessed August 18, 2009
5. Painter J, Rah JH, Lee YK. Comparison of international food guide pictorial representations. *J Am Diet Assoc.* 2002;102:483-489.
6. Giugliano D, Esposito K. Mediterranean diet and metabolic diseases. *Curr Opin Lipidol.* 2008;19:63-68.
7. Lairon D. Intervention studies on Mediterranean diet and cardiovascu-

lar risk. *Mol Nutr Food Res.* 2007;51:1209-1214.
8. Tavani A, La VC. Fruit and vegetable consumption and cancer risk in a Mediterranean population. *Am J Clin Nutr.* 1995;61:1374S-1377S.
9. Renaud S, de LM, Delaye J, et al. Cretan Mediterranean diet for prevention of coronary heart disease. *Am J Clin Nutr.* 1995;61:1360S-1367S.
10. Mettler S, Mannhart C, Colombani PC. Developement and validation of a food pyramid for Swiss athletes. *Int J Sport Nutr Exerc Metab.* 2009;19:504-518.
11. Walter P, Infanger E, Mühlemann P. Food Pyramid of the Swiss Society for Nutrition. *Ann Nutr Metab.* 2007;51(Suppl 2):15-20.
12. Kennedy E. Building on the pyramid: where do we go from here? *Nutr Today.* 1998;33:183-185.
13. Nestle M. In defense of the USDA Food Guide Pyramid. *Nutr Today.* 1998;33:189-197.
14. Britten P, Marcoe K, Yamini S, et al. Development of food intake patterns for the MyPyramid Food Guidance System. *J Nutr Educ Behav.* 2006;38:S78-S92.
15. Manore MM, Meyer NL. *Sport Nutrition for Health and Performance.* 2nd ed. Champaign, IL: Human Kinetics; 2009.
16. Houtkooper, L. *Winning Sports Nutrition Manual.* Tucson, AZ: University of Arizona Corporate Extension; 1994.
17. Messina V, Melina V, Mangels AR. A new food guide for North American vegetarians. *J Am Diet Assoc.* 2003;103:771-775.
18. Larson-Meyer E. *Vegetarian Sports Nutrition.* 1st ed. Champaign, IL: Human Kinetics; 2007.
19. Crotty P, Cert D. The Mediterranean diet as a food guide: the problem of culture and history. *Nutr Today.* 1998;33:227-232.
20. Gifford KD. The Mediterranean diet as a food guide: the problem of culture and history. *Nutr Today.* 1998;33:233-243.
21. Wilson CS. Mediterranean diets: once and future? *Nutr Today.* 1998;33:246-249.
22. Rodriguez NR, Di Marco NM, Langley S. American College of Sports Medicine position stand. Nutrition and athletic performance. *Med Sci Sports Exerc.* 2009;41:709-731.
23. Burke LM, Mettler S. A food pyramid for Swiss athletes. *Int J Sport Nutr Exerc Metab.* 2008;18:430-437.
24. Institute of Medicine. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids. Washington, DC: National Academies Press; 2005.
25. Institute of Medicine. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium and Zinc. Washington, DC: National Academy Press; 2001.
26. Institute of Medicine. Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D and Fluroride. Washington, DC: National Academy Press; 1997.
27. Institute of Medicine. Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B6, Folate, Vitamin B12, Pantothenic Acid, Biotin and Choline. Washington, DC: National Academy Press; 2000.
28. Institute of Medicine. Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium and Carotenoids. Washington, DC: National Academy Press; 2000.
29. Institute of Medicine. Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate. Washington, DC: National Academies Press; 2004.
30. Burke LM, Kiens B, Ivy JL. Carbohydrates and fat for training and recovery. *J Sports Sci.* 2004;22:15-30.
31. Tipton KD, Wolfe RR. Protein and amino acids for athletes. *J Sports Sci.* 2004;22:65-79.
32. Burke LM, Cox GR, Culmmings NK, et al. Guidelines for daily carbohydrate intake: do athletes achieve them? *Sports Med.* 2001;31:267-299.
33. Kushner RF, Doerfler B. Low-carbohydrate, high-protein diets revisited. *Curr Opin Gastroenterol.* 2008;24:198-203.
34. Westerterp-Plantenga MS, Luscombe-Marsh N, Lejeune MP, et al. Dietary protein, metabolism, and body-weight regulation: dose-response effects. *Int J Obes* (Lond). 2006;30 Suppl 3:S16-S23.

"This clearly shows that macronutrient recommendations based on %EI are inappropriate in sports nutrition."