
Assessment of Dietary Behaviors, Body Composition, and Cardiovascular Disease Risk among College Club Rugby Team

CARLY R. MACDOUGALL*, GYTIS BALILIONIS‡, and SVETLANA NEPOCATYCH‡

Department of Exercise Science, Elon University, Elon, NC, USA

*Denotes undergraduate student author, ‡Denotes professional author

ABSTRACT

International Journal of Exercise Science 8(4): 403-413, 2015. The purpose of this study was to evaluate dietary behaviors, body composition, and potential cardiovascular disease (CVD) risk factors among college club rugby team players. 15 athletes completed demographics, three 24-hour dietary recalls, body composition and blood lipid profile assessments following an overnight fast. Mean \pm SD age of participants was 20 ± 1 years; weight 81 ± 16 kg; BMI 25.7 ± 3.2 kg/m²; body fat $13 \pm 5\%$; total cholesterol 133 ± 37 mg/dl; high-density lipoprotein 49 ± 18 mg/dl; low-density lipoproteins 77 ± 26 mg/dl; triglycerides 86 ± 34 mg/dl. The results of dietary analysis indicated that carbohydrates comprise $44 \pm 3\%$ (3.2 ± 0.2 g/kg), proteins $21 \pm 5\%$ (1.5 ± 0.4 g/kg), and fats $34 \pm 3\%$ of the total calories. Mean intake of total fat and saturated fat exceeded recommendations of the Acceptable Macronutrient Distribution Range (AMDR). Recommended Dietary Allowances (RDA) were met for most of the micronutrients excluding vitamin A 557 ± 157 μ g/dl (61% RDA) vitamin E 6 ± 0.5 μ g/dl (40% RDA) and potassium 2267 ± 613 μ g/dl (50% RDA) while mean intake for sodium 4276 ± 437 mg/dl was 285% recommended. In addition, mean intake of fiber 18 ± 5 g was 55% below that recommended. At present, most of the participants were at low risk for developing CVD. However, continuous high intake of total and saturated fat, sodium and low fiber may lead to increased risk for developing CVD.

KEY WORDS: Cholesterol, heart disease, nutrient intake, athletes, performance

INTRODUCTION

Overweight and obesity continue to be a major public health concern in the United States with prevalence rates tripling over the past 50 years from 13% of US adults being obese in 1960 to 36% of US adults in May 2010 (30). Reports indicate that approximately 66% of the US population is considered to be overweight or obese based on body mass index (BMI) collected in the 2003-2004 National Health and Nutrition Examination Survey (35). Overweight and

obesity are the major risk factors for other chronic diseases, including metabolic syndrome, diabetes, and cardiovascular disease (CVD) (26).

While obesity has a complex etiology, lifestyle factors such physical activity, appropriate nutrition, and maintaining energy balance have been cited as key strategies for obesity prevention (18, 27). Despite this knowledge, only 48% of adults meet physical activity guidelines for cardiovascular and muscle-strengthening

activities (8). While athletes are very physically active, it has been suggested that physical activity alone does not eliminate the CVD risk, particularly in strength athletes that have a high BMI (52). Research has shown that the average weight of football players has increased steadily and at the present time, 35% of football players are considered obese and 17.6% of players at an increased risk of developing coronary heart disease, based on waist circumference and percent body fat measurement (28, 47). Additionally, NFL linemen had a 52% greater chance of coronary heart disease mortality compared to general population (28).

In order to promote overall health and optimal performance, sports nutrition guidelines have been generated to help athletes achieve optimal health while performing adequately (40, 43). Typically, athletes require more energy to maintain weight and muscle mass; therefore, their intake should be matched to their energy expenditure (40, 43). For strength athletes, a carbohydrate intake of 6-10 g/kg/d is recommended in order to maintain blood glucose levels during exercise and replace muscle glycogen following exercise (40,43,50). In addition, team and strength athletes should obtain 1.2 to 1.7 g/kg/d of protein to maintain muscle mass (20, 38, 50). Currently, there is no evidence suggesting a need for altered fat intake for athletic performance; therefore, fats should still comprise 20% to 35% of total energy, with less than 10% of fat coming from saturated fats, in order to provide essential fatty acids and vitamins A, D, E and K (40, 50).

However, research has shown that males typically exceed the Dietary Guidelines for Americans (DGAs) for fat, saturated fat, cholesterol, sodium and tend to consume less fruits, vegetables, and dairy products compared to female collegiate athletes (10, 20). Excessive consumption of saturated fat, cholesterol, and sodium has been associated with high serum cholesterol and lipid levels and, consequently, future cardiovascular events (41, 42). Additionally, this type of diet is associated with an increased risk for hypertension and diabetes, which increases the individual's risk for developing cardiovascular disease (41). Therefore, athletes should obtain their calories from the nutrient-dense sources and should maintain appropriate balance between carbohydrates, protein, and fats to prevent future CVD (43).

There have been many studies assessing CVD risk in football players at the amateur and professional level, however, very few studies assessing rugby players. Similar to football players, ideal physical characteristics of rugby players include a larger body mass and greater speed, muscular power, and agility (11, 15). Therefore, the purpose of the current investigation was to analyze typical dietary intake of college rugby players during the off-season training. In addition, we aimed to identify current dietary behaviors associated with CVD risk factors in this specific population.

METHODS

Participants

This investigation utilized a cross-sectional study design to analyze the relationship between typical dietary behaviors and CVD

risk in college club rugby players during the off-season. Participants completed four sessions including: baseline data collection, completion of three 24-hour dietary recalls, and a dual-energy X-ray absorptiometry (DXA) scan. All data was collected and analyzed between December 2011- June 2013. Study approval was prepared according to the guidelines and obtained from local Institutional Review Board.

A purposive sample of male college club rugby players ($n = 15$, 20.3 ± 1.1 years, 81.9 ± 16.5 kg, 207.9 ± 41.8 cm, BMI 25.8 ± 3.0 kg/m²) was recruited for this study. Participants were predominately white (93.3%) and were evenly distributed across college class (freshman 26.7%, sophomore 33.3%, junior 26.7%, and senior 13.3%). Most subjects were classified, based on BMI, as normal weight (46.7%) or overweight (40.0%) with the remainder being classified as obese (13.3%). All participants provided written consent for participation in this study.

Protocol

Participants completed a demographic questionnaire. Height and weight were measured using a stadiometer and scale (DETECTO, Advanced Medical; Carmel, IN); after shoes were removed, height was recorded to the nearest 0.5 cm and weight recorded to the nearest 0.5 kg. BMI was calculated from height and weight, while total energy expenditure was estimated using the Mifflin-St. Jeor equation and an activity factor of 1.6 was used indicating a moderately high level of physical activity (18,32). Waist measurements were taken at the smallest part of the waist followed by hip measurements taken at the largest part of the buttocks using measuring tape.

Waist-to-hip ratio (WHR) was calculated and was used as a measure for central adiposity (12). Body composition was assessed by DXA (Amber Diagnostics, Inc; Orlando, FL). Participants were fasted overnight and refrained from working out 24 hours prior to the procedure. They reported to the lab early in the morning to complete a 15-minute full body composition scan.

Following an overnight fast of at least 8 hours, finger-stick blood samples were collected to analyze high-density lipoprotein (HDL), total cholesterol (TC), triglycerides (TG), and the HDL/TC ratio using a blood chemistry analyzer (CardioChek PA, Polymer Technology Systems, Inc; Indianapolis, IN). The CardioChek PA analyzer allows for a quick accurate assessment of TC ($R^2 = 0.984$; total error (TE) = 4.7%), HDL cholesterol ($R^2 = 0.9786$; TE = 5.9%), and TG ($R^2 = 0.97$) (33,35,50). Total cholesterol, HDL, and TG values were used to calculate low-density lipoproteins (LDL) using the Friedewald equation (36). All baseline measurements were collected by the same researcher.

Each participant was asked to complete three 24-hour dietary recalls in which two weekdays and one weekend day were analyzed when participants did not workout. 24-hour dietary recalls were completed using the USDA Five-Step Multiple-Pass Method (10). All recalls were analyzed for macronutrient and micronutrient content and compared to the Dietary Reference Intakes (DRI) for their gender and age group. A detailed handout including charts and visual models was provided to inform each participant how to track food appropriately. For food recalls,

participants were expected to recall the time at which they ate, a detailed breakdown of what they ate making sure to separate combination foods, the amount they ate, where they ate, and method of preparation. They were asked to do this for each meal, snack, and drink consumed on the previous day. 24-hour recalls were supervised by the same researcher during individual sessions.

Statistical Analysis

Statistical analyses were performed using statistical analysis software (SPSS version 12.0 for Windows, SPSS Inc, Chicago, IL). Descriptive statistics (mean \pm standard deviation) are reported for subject demographic characteristics, cardiovascular risk factors, and food recall variables. Bivariate correlations were used to assess the relationship between dietary patterns (i.e., fruit and vegetable servings and daily fiber) and CVD risk factors (i.e., total cholesterol LDL cholesterol, TC to HDL-C ratio, triglycerides, BMI, body fat percent, and waist-to-hip ratio). Paired sample t-tests were performed to assess the difference between participant dietary intake and recommendations; for macronutrient ranges, participant values were assessed against the minimum and maximum within the range. Macronutrient intake was considered lower than recommendations if the difference between the actual intake and recommendation was negative and significantly different from the minimum value. Macronutrient intake was considered higher than recommendations if the difference between the actual intake and recommendation was positive and significantly different from the maximum value. Statistical significance was indicated by an alpha value less than 0.05.

RESULTS

A final sample of 15 participants completed the study; two participants were excluded from data analysis due to incomplete dietary intake data. The characteristics of the participants and cardiovascular disease (CVD) risk factors are presented in Table 1. While individual participants posed certain risk factors, such as high TC, TG, and LDL, overall the sample was a healthy population that demonstrated low risk for CVD.

Table 1. Characteristics of participants (n=15).

Characteristic	Participants ^a (n=15)	CVD Risk Factors ^b
Age (yr)	30.2 \pm 1.1	\geq 45
Weight (lb)	179.4 \pm 36.1	----
BMI (kg/m ²)	25.8 \pm 3.0	\geq 30
DXA (%BF)*	18.5 \pm 8.9	\geq 22
W:H Ratio	0.82 \pm 0.04	\geq 1.0
TG (mg/dL)	87.9 \pm 34.4	\geq 150
TC (mg/dL)	132.3 \pm 35.8	$>$ 200
HDL (mg/dL)	49.8 \pm 17.7	$<$ 40
LDL (mg/dL)	66.7 \pm 25.0	$>$ 130

Note. ^aParticipant data is reported as mean \pm s.d.
^bCVD risk factor data based on ACSM guidelines.
 *Two participants did not complete the DXA scan (n=13).

The mean macronutrient and micronutrient intakes for the participants are presented in Table 2 and Table 3. Male athletes did not meet the recommended intake for energy, carbohydrates (CHO), and fiber. On average, athletes consumed 521 kilocalories below the recommended intake, 2900 kcal/day, for moderately active males aged 19-30 years ($p = 0.004$) and 770 kilocalories below calculated total energy expenditure ($p = 0.002$). As presented in Table 2, CHO consumption expressed in grams per kilogram of body weight (3.4 ± 1.1 g/kg body weight; $p < 0.001$) was below the general recommendations for athletes (6-10

Table 2. Participants' macronutrient and fiber intakes.

Nutrient	Recommended Intake (Males 19-30 y)	Participants Intake (n=15)	p-value ($\alpha = 0.05$)
Energy			
Kcal ^b	2900	2378 ± 126*	0.004
Carbohydrate			
g/kg BW ^d	5-10	3.4 ± 1.1*	<0.001
% energy ^c	45-65	34 ± 3	0.773
Fat			
% energy ^c	20-35	34 ± 3	
Saturated Fat			
g ^b	<32	32 ± 3.5	0.746
% energy ^c	<10	12 ± 0.5	0.132
Protein			
g/kg BW ^d	1.2-1.7	1.7 ± 0.8	0.947
% energy ^c	10-35	21 ± 5	0.315
Fiber (g) ^{c*}	38	18.8 ± 6.3*	<0.001

Note. ^aIntakes reported as mean ± s.d. Recommendations based on the Recommended Dietary Allowances, ^bDietary Guidelines, ^cthe American Dietetic Association, ^dand Rogozkin, V.A. ^e

*denotes significantly under recommended levels and ** denotes significantly above recommended levels.

g/kg of bodyweight); CHO comprised 45.6 ± 8.3% of total kilocalories, which was at the lower limit of the AMDR range. Participants only consumed half of the recommended daily intake of fiber (18.8 ± 6.3 g/d; $p < 0.001$). This could be due to low intakes of fruits (0.82 ± 0.64 servings/day) and vegetables (1.3 ± 0.81 servings/day). Low intakes of fruit and fiber were associated with a higher percent body fat ($r = -0.533$ and $r = -0.579$, respectively), WHR ($r = -0.475$ and $r = -0.583$, respectively), BMI ($r = -0.626$ and $r = -0.446$, respectively), and BMI classification ($r = -0.468$ and $r = -0.531$, respectively). Additionally, reported milk intake was lower than that recommended (1.6 ± 0.79 servings/day). Meanwhile, reported consumption of grains (6.9 ± 2.2 servings/day) met Dietary Guidelines and consumption of meat/beans (11.2 ± 7.7 oz/day) exceeded recommendations.

Fat (1.2 ± 0.48 g/kg of body weight; 34.1 ± 6.0%) and protein (1.7 ± 0.82 g/kg of body weight; 21.2 ± 4.8%) were within acceptable ranges (Table 2). While saturated fat (12 ± 0.5%) and cholesterol (372.9 ± 260.4 mg/d) exceeded the recommendations, these findings were not considered significant ($p = 0.746$ and $p = 0.2875$, respectively). However, sodium intake was 285% more than recommended ($p < 0.001$) by the Dietary Guidelines (Table 3). Typically, diets that were high in total calories were strongly correlated with high intakes of total fat ($r = 0.848$; $p < 0.001$), saturated fat ($r = 0.688$; $p < 0.001$), and sodium ($r = 0.605$; $p = 0.017$). Participants were below the recommended intakes for vitamin E ($p < 0.001$), potassium ($p < 0.001$), and magnesium ($p = 0.048$) (Table 3).

Table 3. Participants' micronutrient intakes.

Nutrient	Recommended Intake (Males 19-30 y)	Participants Intake (n=15)	p-value ($\alpha = 0.05$)
Vitamin A (μg)	900	654 \pm 559	0.111
Vitamin C (mg)	90	133 \pm 125	0.210
Vitamin E (mg)	15	5 \pm 8*	0.001
Vitamin B ₆ (mg)	1.3	2 \pm 1**	0.022
Vitamin B ₁₂ (μg)	2.4	4 \pm 3**	0.011
Thiamin (mg)	1.2	1.5 \pm 0.5	0.099
Riboflavin (mg)	1.3	1.5 \pm 0.7	0.213
Niacin (mg)	16	29 \pm 15**	0.004
Folate (μg)	400	388 \pm 248	0.851
Calcium (mg)	1000	1073 \pm 620	0.654
Iron (mg)	8	18 \pm 11**	0.003
Zinc (mg)	11	12 \pm 7	0.649
Phosphorous (mg)	700	1294 \pm 725**	0.007
Potassium (mg)	4700	2404 \pm 1060*	0.001
Magnesium (mg)	400	308 \pm 45*	0.048
Selenium (μg)	55	292 \pm 193**	0.001
Cholesterol (mg)	<300	373 \pm 260	0.2875
Sodium (mg)	<2300	4294 \pm 2129**	0.001

Note. ¹Recommendations based on Dietary Reference Intakes (USDA USDHHS, 2010); ²Intakes were reported as mean \pm s.d. *indicates significantly below DRI, ** indicates significantly above DRI.

DISCUSSION

Adequate nutrition is important for athletic performance as well as disease prevention. While college athletes have been considered the epitome of health because they look physically fit, the results of this study indicate that they are a vulnerable population susceptible to nutrient-based inadequacies. While none of the athletes in the present study exhibit cardiovascular disease risk factors, several other key findings emerged.

In the present study, energy intakes were observed among collegiate club rugby male athletes that were well below the energy recommendations for their age group, which is well-supported by other studies

observing football and basketball players (20). One postulation about low energy intakes reported by athletes is related to improved energy efficiency, which is a phenomenon characterized by an athlete's ability to balance their basal metabolic needs and energy costs of exercise at a substantially lower energy intake than expected (5). However, existing evidence indicates that underreporting is the more likely cause of reported energy intakes that are lower than recommended (5, 19). In a general population, self-reported energy intake is generally 20% lower than true energy intake and may be as extreme as 34% in athletes based on doubly labeled water estimates of total energy expenditure (5, 19). Since underreporting is widespread across populations and diet analysis

methodologies, this makes it especially difficult for sports dietitians to recommend specific energy and nutrient requirements, which may negatively impact both health and performance (4, 5, 19).

Despite the potential for underreporting, the results of this study are aligned with existing literature that indicate carbohydrate needs are not being met for this sample population (40, 50). Hinton et al. stated that approximately 10% of male athletes met the minimum recommendation of 6g of carbohydrate per kg of body weight while Baker et al. reported 18% of consumed appropriate amounts of carbohydrates during practice (2, 20). Carbohydrates are a critical source of energy during exercise due to its roles in fatigue prevention and recovery following a training session (1, 7, 30). Therefore, consumption of carbohydrate-rich snacks and meals, particularly following exercise, is advantageous for athletes (7). While high-glycemic foods are essential for recovery following an exercise bout, low glycemic foods, such as fruits, vegetables and whole grains that contain dietary fiber, should be included as part of a well-balanced nutrient-dense diet. However, the athletes observed in this study only consumed 50% of the recommendations for fiber. It is possible that these athletes are replacing whole foods with processed foods. Low consumption of fiber and high consumption of processed foods, particularly those with a high-glycemic index, may lead to impaired glucose control, higher TC and LDL; the change in these risk factors may lead to an increased risk for CVD (13, 40, 50). Additionally, the results of the current study indicate that low fruit and vegetable consumption was

associated with higher percent body fat, waist-to-hip ratio, BMI, and BMI classification all of which have been used as risk factors for CVD (3, 22, 52).

While carbohydrate intake did not meet recommended values, protein and fat intakes were within the recommended ranges. Although not statistically significant, there was a general trend of higher intake for saturated fat and cholesterol than that recommended. A previous study by Hinton et al. observed intakes for fat ($32.0 \pm 5.6\%$), saturated fat ($10.9 \pm 2.4\%$), and sodium (2942 ± 1319) that exceed the Dietary Guidelines (20). The typical male-athlete diet is characterized by a high intake of saturated fat paired with sodium; this could raise TC and LDL while simultaneously increasing the risk for hypertension (20, 41).

Furthermore, research has found that male athletes commonly report micronutrient deficiencies in vitamin E and magnesium (20). The results from the present study indicate that athletes consume inadequate amounts of vitamin E, magnesium, and potassium. These micronutrients function in immunity and metabolic pathways, but more importantly they may convey cardio-protective properties (21, 31, 41, 48). Vitamin E is an antioxidant that can reduce or prevent oxidative damage, which is important to eliminate reactive oxygen species from exercise and to combat arterial wall damage by buffering free radicals that cause the oxidation of LDL (41, 46, 49). Vitamin E is commonly found in nuts and seeds, but can also be found in substantive quantities in dark green leafy vegetables; therefore, low vegetable intake observed in this study could potentially explain

inadequate intake of vitamin E while low intakes of dairy products could explain the lack of certain minerals consumed by the athletes. Potassium and magnesium are important components of dairy products (41).

While many of the results presented are consistent with existing literature, results should be interpreted with caution. The current study had a small sample size (n+15). An additional limitation is the reliance on self-report data for dietary assessment. Utilizing 24-hour recalls completed on multiple days, including weekdays and weekend days, is a reliable and valid assessment for dietary intake; however, there is great individual variation and subject specific bias, which may affect the ability to observe true dietary intake and the potential relationship between specific dietary factors and CVD risk factors (10, 19). Underreporting may be due to social desirability bias, which tends to influence reporting on food consumption (sweets, high-fat foods, alcohol) and may impact the results of this study (10). Finally, weight status was characterized using BMI, which can misidentify athletes as overweight based on muscle mass; however, BMI was only one tool used to identify weight status among a conglomerate of DEXA body fat percentage, waist measurement, and WHR (3, 26, 34, 53).

Despite limitations of this study, the consensus remains that male athletes tend to underreport energy expenditure, which can make macronutrient distributions and micronutrient deficiencies more difficult to assess. Current literature has presented how critical proper nutrition behaviors are

when leading a healthy life. For this population, immediate concerns for performance typically trump concerns about future disease risk. Therefore, athletes are more likely to perpetuate inadequate nutrition behaviors, such as consuming low intakes of fiber while simultaneously consuming high intakes of sodium, cholesterol, and saturated fat. This puts them at a greater risk of developing cardiovascular disease later in life, which further contributes to the current epidemic. The results of the present study indicate that athletes may benefit from access to a dietitian that specializes in sport's performance nutrition. In order to promote optimal athletic performance and lifelong health, dietary behavior change is necessary. Athletes should be advised to derive most of their energy from fiber-rich carbohydrate, such as fresh fruits and vegetables and whole grains (21). Additionally, athletes should receive education about appropriate fueling before, during, and following exercise to enhance athletic performance and promote recovery. While these changes could make a great difference, the findings of this study indicate that these athletes would benefit most from a comprehensive nutrition education to help them make healthier food choices that are appropriate for competition, as well as, long-term health. Athletes should be educated on the appropriate macro- and micro-nutrient distribution in their diet and appropriate choices in each of the food groups to delay onset of CVD risk factors.

REFERENCES

1. Balsom PD, Gaitanos GC, Soderlund K, Ekblom B. High-intensity exercise and muscle glycogen

- availability in humans. *Acta Physiol Scand* 165: 337-345, 1999.
2. Baker LB, Heaton LE, Nuccio RP, Stein KW. Dietitian-observed macronutrient intakes of young skill and team-sport athletes: adequacy of pre, during, and post-exercise nutrition. *Int J Sport Nutr Exerc Metab* 24(2): 166-176, 2014.
 3. Bennasar-Veny M, Lopez-Gonzalez AA, Tauler P, Cespedes ML, Vicente-Herrero T, Yanez A, Tomas-Salva M, Aguilo A. Body adiposity index and cardiovascular health risk factors in Caucasians: a comparison with the body mass index and others. *PLoS One* 8(5): e63999, 2013.
 4. Black AE, Cole TJ. Biased over- or under-reporting is characteristic of individuals whether over time or by different assessment methods. *J Am Diet Assoc* 101(1): 70-80, 2001.
 5. Burke LM. Energy needs of athletes. *Can J Appl Physiol* 26(Supp1): S202-S219, 2001.
 6. Burke LM, Loucks AB, Broad N. Energy and carbohydrate for training and recovery. *J Sports Sci* 24: 675-685, 2006.
 7. Burke LM, Kiens B, Ivy JL. Carbohydrates and fat for training and recovery. *J Sports Sci* 22: 15-30, 2004.
 8. Centers for Disease Control and Prevention. Facts about physical activity. (May 30, 2014). Retrieved from: <http://www.cdc.gov/physicalactivity/data/facts.html>.
 9. Cole CR, Salvaterra GF, Davis JE, Borja ME, Powell LM, Dubbs EC, Bordi PL. Evaluation of dietary practices of National Collegiate Athletic Association Division I football players. *J Strength Cond Res* 19(3): 490-494, 2005.
 10. Conway JM, Ingwersen LA, Moshfegh AJ. Accuracy of dietary recall using the USDA five-step multiple-pass method in men: an observational validation study. *J Am Diet Assoc* 104(4): 595-603, 2004.
 11. Cunniffe B, Procor W, Baker JS, Davies B. An evaluation of the physiological demands of elite rugby union using global position system tracking software. *J Strength and Cond Res* 23(4): 1195-1203, 2009.
 12. Dalton M, Cameron AJ, Zimmet PZ, Shaw JE, Jolley D, Dunstan DW, Welborn TA. *J Intern Med* 254: 555-563, 2003.
 13. Eilat-Adar S, Sinai T, Yosefy C, Henkin Y. Nutritional recommendations for cardiovascular disease prevention. *Nutrients* 5: 3646-3683, 2013.
 14. Froiland K, Koszewski W, Hingst J, Kopecky L. Nutritional supplement use among college athletes and their sources of information. *Int J of Sports Nutr Exerc Metab*, 14: 104-120, 2004.
 15. Gabbet TJ. Physiological characteristics of junior and senior rugby league players. *Br J Sports Med* 36: 334-339, 2002.
 16. Gabel KA. Special nutritional concerns for the female athlete. *Curr Sports Med Rep* 5:187-191, 2006.
 17. Gupta AK, Johnson WD, Johnansen D, Ravussin E. Cardiovascular risk escalation with caloric excess: a prospective demonstration of the mechanics in healthy adults. *Cardiovasc Diabetol* 12:23-34, 2013.
 18. Hasson RE, Howe CA, Jones BL, Freedson PS. Accuracy of four resting metabolic rate prediction equations: effects of sex, body mass index, age, and race/ethnicity. *J Sci Med Sport* 14(4): 344-351, 2011.
 19. Hill RJ, Davies PSW. The validity of self-reported energy intake as determined using doubly labelled water technique. *Br J Nutr* 85: 415-430, 2001.
 20. Hinton PS, Sandford TC, Davidson MM, Yakushko OF, Beck NC. Nutrient intakes and dietary behaviors of male and female collegiate athletes. *Int J Sports Nutr Exerc Metab* 14: 389-405, 2004.
 21. Insel P, Ross D, McMahon K, Bernstein. Nutrition. Jones and Bartlett Publishers; Sudbury, Massachusetts, 2011.
 22. Islami F, Manczuk M, Vedanthan R, Vatten L, Polewczyk A, Fuster V, Boffetta P, Zatonski WA. A cross-sectional study of cardiovascular disease and associated factors. *Ann Agric Environ Med* 18(2): 255-259, 2011.

23. Jacobson BH, Aldana SG. Current nutrition practice and knowledge of varsity athletes. *J App Sport Sci Res*, 6: 232-238, 1992.
24. Jacobson BH, Sobonya C, Ransone J. Nutrition practices and knowledge of college varsity athletes: a follow-up. *J Strength Cond Res* 15: 63-68, 2001.
25. Kaul S, Rothney MP, Peters DM, Wackler WK, Davis CE, Shapiro MD, Ergun DL. Dual-energy X-ray absorptiometry for quantification of visceral fat. *Obesity* 20(6): 1313-1318, 2012.
26. King DE, Mainous AG, Matheson EM, Everett CJ. Impact of healthy lifestyle on mortality in people with normal blood pressure, LDL cholesterol, and c-reactive protein. *Eur J Prev Cardiol* 20(1): 73-79, 2013.
27. Loucks AB. Energy balance and body composition in sports and exercise. *J Sport Sci*, 22: 1-14, 2004.
28. Matthew M, Wagner DR. Prevalence of overweight and obesity in collegiate American football players, by position. *J Am Coll Health* 57(1): 33-38, 2008.
29. Martin SL, Hardy TM, Tollefsbol TO. Medicinal chemistry of the epigenetic diet and caloric restriction. *Curr Med Chem* 20(32): 4050-4059, 2013.
30. May AL, Freedman D, Sherry B, Blanck HM, CDC. Obesity - United States, 1999-2010. *MMWR Surveill Summ* 62(3): 120-128, 2013.
31. McCollough FS, Northrop-Clewes CA, Thurnham DI. The effect of vitamin A on epithelial integrity. *Proc Nutr Soc* 58(2): 289-293, 1998.
32. Meeusen R, Watson P, Dvorak J. The brain and fatigue: new opportunities for nutritional interventions? *J Sports Sci*, 24(7): 773-782, 2006.
33. Mifflin MD, St. Jeor ST, Hill LA, Scott BJ, Daugherty SA, Koh YO. A new predictive equation for resting energy expenditure in healthy individuals. *Am J Clin Nutr* 51(2): 241-247, 1990.
34. Ode JJ, Pivarnik JM, Reeves MJ, Knous JL. Body mass index as a predictor of percent fat in college athletes and nonathletes. *Med Sci Sports Exerc* 39(3): 403-409, 2007.
35. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. *JAMA* 295: 1549-1555, 2006.
36. Oliveira MJ, van Deventer HE, Bachmann LM, Warnick GR, Nakajima K, Nakamura M, Sakurabayashi I, Kimberly MM, Shamburek RD, Korzun WJ, Myers GL, Miller WG, Remaley AT. Evaluation of four different equations for calculating LDL-C with eight different direct HDL-C assays. *Clin Chim Acta* 423: 135-140, 2013.
37. Panz VR, Raal FJ, Paiker J, Immelman R, Miles H. Performance of the CardioChek PA and Cholestech LDX point-of-care analysers compared to clinical diagnostic laboratory methods for the measurement of lipids. *Cardiovasc J S Afr* 16(2): 112-117, 2005.
38. Phillips SM. Protein requirements and supplementation in strength sports. *Nutrition* 20: 689-695, 2004.
39. Polymer Technology Systems, Inc. Accuracy and precision in point-of-care lipid testing: CardioChek P-A Point-of-Care Test System and PTS Panels Test Strips. 2007.
40. Ray TR, Fowler R. Current issues in sports nutrition in athletes. *South Med J* 97(9): 863-866, 2004.
41. Reddy KS, Katan MB. Diet, nutrition, and the prevention of hypertension and cardiovascular diseases. *Public Health Nutr* 7(1A): 167-186, 2004.
42. Ridker PM, Rifai N, Cook NR, Bradwin G, Buring JE. Non-HDL cholesterol, apolipoproteins A-1 and B₁₀₀, standard lipid measures, lipid ratios, and CRP as risk factors for cardiovascular disease in women. *JAMA* 294(3): 326-333, 2005.
43. Rodriguez NR, DiMarco NM, Langley S. Position of the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine. *J Am Diet Assoc* 109(3): 509-527, 2009.

DIETARY BEHAVIORS AND CVD RISK IN COLLEGIATE ATHLETES

44. Rogozkin VA. Weightlifting and power events. In: Maughan RJ, ed. *Nutrition in Sport*. Malden, MA: Blackwell Science; 621-631, 2000.
45. Rosenbloom CA, Jonnalagadda SS, Skinner R. Nutrition knowledge of collegiate athletes in a Division I National Collegiate Athletic Association Institution. *J Am Diet Assoc* 102(3): 418-420, 2002.
46. Ryan MJ, Dudash HJ, Docherty M, Geronilla KB, Baker BA, Haff GG, Cutlip RG, Always SE. Vitamin E and C supplementation reduces oxidative stress, improves antioxidant enzymes and positive muscle work in chronically loaded muscles of aged rats. *Exp Gerontol* 45(11): 882-895, 2010.
47. Selden MA, Helzber JH, Waeckerle. Early cardiovascular mortality in professional football player: fact or fiction? *Am J Med* 122(9): 811-814, 2009.
48. Semba RD. The role of vitamin A and related retinoids in immune function. *Nutr Rev* 56(1): S38-S48, 1998.
49. Sen CK. Antioxidants in exercise nutrition. *Sports Med* 31(13): 891-908, 2001.
50. Shriver LH, Betts NM, Wollenberg G. Dietary intakes and eating habits of college athletes: are female college athletes following the current sports nutrition standards? *J Am Coll Health* 61(1): 10-16, 2013.
51. Slavin JL. Position of the American Dietetic Association: health implications of dietary fiber. *J Am Diet Assoc* 108(10): 1716-1731, 2008.
52. Tucker AM, Vogel RA, Lincoln AE, Dunn RE, Ahrensfield DC, Allen TW, Castle LW, Heyer RA, Pellman EJ, Strollo PJ, Wilson PW, Yates AP. Prevalence of cardiovascular disease risk factors among National Football League players. *JAMA* 301(20), 2111-2119, 2009.
53. US Department of Agriculture, US Department of Health and Human Services. *Dietary Guidelines for Americans, 2010*. 7th ed, Washington, DC: U.S. Government Printing Office 2010.
54. Van Dijk SB, Takken T, Prinsen EC, Wittink H. Different anthropometric adiposity measures and their association with cardiovascular disease risk factors: a meta analysis. *Neth Heart J* 20(5): 208-218, 2012.
55. Whitehead SJ, Ford C, Gama R. A combined laboratory and field evaluation of the Cholestech LDX and CardioChek PA point-of-care testing lipid and glucose analysers. *Ann Clin Biochem*: 1-14, 2013.