Nutrition and Hydration Status of Junior Elite Female Soccer Athletes

by

Jennifer Gibson
BASc, Ryerson University, 2003

A Thesis Submitted in Partial Fulfillment
of the Requirements for the Degree of

MASTER OF SCIENCE

in the School of Exercise Science, Physical and Health Education

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Abstract

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The junior elite female athlete is faced with the unique challenge of fuelling and hydrating for sport performance as well as growth and development. Very little published data have comprehensively described the nutrition and hydration status of adolescent female athletes, therefore, the aim of this study was to report fluid balance and sweat sodium concentration data, anthropometrics, hematological analysis as well as dietary intake of thirty-four junior elite female soccer athletes (15.7 ± 0.7 years). Hydration assessment (pre-training urine specific gravity, USG), fluid balance and sweat sodium concentration) was conducted during two 90 minute, on-field, group training sessions in mild/cool temperatures (9.8 ± 3.3 °C, 63.0 ± 12.4% relative humidity). Athletes completed four-day food records, hematological analysis (iron status markers, prealbumin and 25-hydroxyvitamin D), and anthropometric assessment. Results revealed mean body composition of players was 103.1 ± 35.2mm (sum of seven skinfolds) and 20.2 ± 5.4% body fat. The mean pre-training USG was 1.018 ± 0.009, with 45.4% of players in a hypohydrated state (USG >1.020). Players experienced a mean body mass loss of 0.84% ± 0.07%, sweat rates of 458.8 ± 284.9 ml/hour and sweat sodium concentration of 47.6 ± 11.9mmol/L during training sessions. Mean fluid intake within
the 90 minute training sessions was 195 ± 0.24ml. Less than 1 litre of fluid was consumed by 100% of all participants during training sessions. Limited opportunity for fluid consumption was observed during training, with 6 of 7 sessions providing only a single fluid break. Mean energy intake was 2079 ± 460kcal/day. Mean macronutrient intake, carbohydrate (5.0 ± 1.6g/kg), protein (1.38± 0.3g/kg) and fat (29.9± 5.8%), met current Dietary Reference Intakes (DRIs) and sport nutrition recommendations however, 51.5% of athletes reported consuming <5g/kg carbohydrate. When compared to DRIs, mean intake of several micronutrients were below recommendations including pantothenic acid, vitamin D, folate, vitamin E, and calcium. The majority of athletes presented with serum 25-hydroxyvitamin D, prealbumin and iron markers within normal clinical ranges however when compared to recommendations for athletic populations, 89.3% and 50.0% of participants had suboptimal iron and 25-hydroxyvitamin D stores respectively. In summary, junior elite female soccer players experienced similar sodium losses and fluid losses to research reported in female adult players. The hypohydrated state, low consumption of fluids during training, which was typically devoid of sodium, and the limited access to fluids during training provide evidence of less than optimal hydration practices. Players were not in energy balance, and many athletes failed to meet carbohydrate and micronutrient requirements. When compared to recommendations for athletic populations, players may be at risk for iron depletion and suboptimal vitamin D status. More research is needed to confirm and support these findings and further develop an understanding of the unique nutrition and hydration needs of the female adolescent athlete. These findings can be used to inform nutrition and hydration practice guidelines and research for players, coaches and sport nutrition professionals.
# Table of Contents

Supervisory Committee ........................................................................................................... ii

Abstract ........................................................................................................................................ iii

Table of Contents ...................................................................................................................... v

List of Tables ............................................................................................................................. vi

List of Figures ........................................................................................................................... vii

Acknowledgments .................................................................................................................... viii

Dedication ................................................................................................................................. ix

Chapter 1: Introduction ............................................................................................................. 1

Chapter 2: Methods ................................................................................................................... 8

Chapter 3: Results ..................................................................................................................... 21

Chapter 4: Discussion ................................................................................................................ 38

References ................................................................................................................................. 64

Appendix A: Review of Literature ........................................................................................... 77

Appendix B: Consent Form ....................................................................................................... 94

Appendix C: Nutrition Questionnaire/Food Recording Sheets ................................................. 97

Appendix D: Anthropometry Data Collection Sheet ................................................................. 104

Appendix E: Environmental Data Collection Sheet ................................................................. 105

Appendix F: Hydration Testing Sheet ....................................................................................... 106

Appendix G: Data Collection Protocol .................................................................................... 107

Appendix H: Participants Results Form .................................................................................. 110
List of Tables

Table 1: Summary of 4-week Data Collection Protocol .................................................. 9

Table 2: Participant Anthropometric Characteristics and Self Reported Weekly Training Volume (n =33) .......................................................................................................................... 22

Table 3: Environmental Conditions for Soccer Training Sessions .................................. 23

Table 4: Heart Rate (bpm), Percent HR Max and Time (minutes) Spent at Differing Levels of Intensity During Soccer Training Sessions ......................................................... 24

Table 5: Participant Body Mass Changes, Fluid Consumption and Sweat Loss During Soccer Training Sessions ........................................................................................................... 27

Table 6: Sweat Sodium Concentration Across Different Regional Sites ............................ 28

Table 7: Estimated Energy Expenditure (EEE) and Energy Intake of Participants Relative to Common Recommendations (n =33) ................................................................. 30

Table 8: Macronutrient Intake of Participants and the Proportion of Participants Not Meeting Dietary Reference Intakes (DRI’s) and Sport Nutrition Recommendations (n =33) ................................................................................................................... 32

Table 9: Dietary Intake of Micronutrients Relative To Dietary Reference Intakes (DRIs) Recommendations (n =33) .............................................................................................................. 34

Table 10: Hematological Parameters of Iron Related Indices, Vitamin D and Pre-albumin of Study Participants (n =28) ............................................................................................................. 36

Table 11: Total Iron Binding capacity (TIBC), Transferrin Saturation and Plasma Iron Levels of Study Participants (n=16) .................................................................................................. 36

Table 12: Fluid Intake Practices of Study Participants Compared to Adult and Youth Hydration Guidelines .......................................................................................................................... 44

Table 13: Comparison of Hydration, Fluid Balance and Sweat Sodium Loss from Present and Previous Data Involving Soccer Athletes ................................................................. 48

Table 14: Summary of Dietary Intake Research in Elite Female Athletes from a Variety of Sports ........................................................................................................................................ 90
List of Figures

Figure 1. Pre training urine specific gravity (USG) by age group and combined together ................................................................. 25
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Dedication

This thesis is dedicated to three critical inspirations in my life. To my family, for teaching me the essential values of hard work, tenacity and humour. To my husband, for encouraging and supporting me to turn dreams into realities and now missions accomplished. To the Lord, for showing me such a blessed and rewarding life so far, and for providing me with the life support networks of a loving family and husband.
Chapter 1

The 2006 FIFA “Big Count” Football Worldwide Survey revealed that 26 million women across 132 countries play soccer, with 405,000 female youth players (<18 years old) registered in Canada (FIFA Big Count, 2006). Nutrient needs are higher during adolescence than any other time in the lifecycle, regardless of activity level, due to rapid gains in height and weight, development of secondary sex characteristics and continued neural development (Otten, Hellwig, & Meyers, 2006; Petrie, Stover, & Horswill, 2004; Rosenbloom, Loukes, & Ekblom, 2006; Burke & Deakin, 2007). Soccer is a high intensity, intermittent sport where players can cover approximately 10km during matches and have reported energy expenditures of 1100 - 4500kcal (Rosenbloom et al., 2006). Careful attention to energy, carbohydrate and fluid intake is therefore needed to support optimal training and game performance (Rosenbloom et al., 2006; Rico-Sanz, Zehnder, Buchli, Dambach & Boutellier, 1999; Zehnder, Rico-Sanz, Kuhne, & Boutellier, 2000). The adolescent female soccer athlete is thus faced with the complex challenge of having to nourish and hydrate not only for optimal growth and maturation but also sport performance (Rosenbloom et al., 2006).

During training and competition, adolescent athletes are at risk of dehydration, a state that is known to negatively impact athletic performance (Casa et al., 2000; Sawka et al., 2007; Coyle, 2004). Adolescents, who by definition are still physically maturing, may be at increased risk for heat illness and dehydration due to underdeveloped and less efficient thermoregulation and thirst mechanisms (Iuliano, Naughton, Collier & Carlson, 1998; Rosenbloom et al., 2006). Soccer-related hydration research to date has shown that athletes are not replacing fluid losses during training (Broad, Burke, Cox, Heeley, &
Riley, 1996; Shirreffs, Aragon-Vargas, Chamorro, Maughan, Serratos, & Zachweija, 2005; Maughan, Shirreffs, Merson, & Horswill, 2005; Kilding, Tunstall, Wraith, Good, Gammon, & Smith, 2009; Maughan, Merson, Broad, & Shirreffs, 2004), have higher sweat and electrolyte losses than non-athletes (Mao, Chen, & Ko, 2001), higher sweat rates with increasing age (Mjaanes, Horswill, & Stover, 2006) as well as large inter-individual variation of sweating responses and intake practices (Broad et al.; Shirreffs et al.; Maughan et al.; Kilding et al.). In addition, dehydration in soccer players (adult males and females) has been associated with elevations in core temperature (Rico-Sanz, Frontera, Rivera, Rivera-Brown, Mole, & Meredith, 1996; Ali, Gardiner, Foskett, & Gant, 2010; Edwards et al., 2007), heart rate (Ali et al.), lactate production (Ali et al.), ratings of perceived exertion (Ali et al.; Edwards et al.), as well as a reduction in soccer specific skill and mental test performance (Edwards et al.).

Adolescent athletes participating in high volume training must ensure that they are consuming adequate nutrition in order to fuel performance, enhance recovery, promote training adaptations and optimally grow, develop and mature (Petrie et al., 2004; Rosenbloom et al., 2006; Burke & Deakin, 2007). The repeated, high intensity bouts of activity needed for soccer performance require high energy expenditures with a heavy reliance on carbohydrate as an energy source (Rosenbloom et al.; Rico-Sanz, Zehnder, Buchli, Dambach & Boutellier, 1999; Zehnder, Rico-Sanz, Kuhne, & Boutellier, 2000). Nutrition research conducted in competitive male youth as well as adult female soccer players has demonstrated that athletes are at risk for under consuming energy (Leblanc, Le Gall, Grandjean, & Verger, 2002; Clark, Reed, Stephen, & Armstrong, 2003), carbohydrate (Garrido, Webster, & Chamorro, 2007; Iglesias-Gutiérrez, García-Rovés,
When compared to males, adolescent females athletes are at greater risk for suboptimal energy and carbohydrate intake (Loukes, 2004; Burke, Cox, Cummings, & Desbrow, 2001; Rosenbloom et al., 2006). Although soccer is not a sport in which extreme leanness or thinness is associated, female athletes may feel social influences to maintain a low body weight or fatness and thus reduce caloric intake (Rosenbloom et al.). Female athletes are also at increased risk for iron depletion and deficiency, which may have implications for performance and health (Rosenbloom et al.; Rodrigues, DiMarco, & Langley, 2009). Inadequate intake of these nutrients can compromise not only athletic performance but suboptimal energy and nutrition status can influence hormonal patterns, leading to impairments in growth, performance and bone development (Loukes).

Despite the current growing body of evidence in male adolescent and adult soccer players there is a paucity of data available describing nutrition and hydration assessment
of the junior elite female athlete across all sports including soccer. Of the available hydration literature, fluid balance has been assessed in one study of female adolescent players (Broad et al., 1996). Comprehensive assessment of hydration and electrolyte losses using such methods as sweat sodium and urine specific gravity analysis has not been published in female adolescent players. No published study to date has comprehensively investigated the nutrition status (via anthropometry, serum measures and dietary intake analysis) of adolescent female soccer players. Nutrition research available in the female adolescent athlete population has focused primarily in sports which emphasize a lean physique or weight class such as gymnastics (Jonnalagga, Benardot, & Nelson, 1998), swimming (Farajian, Kavouras, Yannakoulia, & Sidossis, 2004; Hassapidou, Valasiadou, Tzioumakis, & Vrantza, 2002) and judo (Kim, Kim, Kim, & Park, 2002) or other team sports like volleyball (Papadopoulou, Papadopoulou, & Gallos, 2002). Due to the differences in physique demands, energy systems used by the sport and environmental conditions in which the athlete competes, this data is difficult to relate to soccer athletes.

There is currently no available Canadian nutrition and hydration literature in soccer athletes (across all age and genders), with the majority of soccer related research coming from Europe, New Zealand and the USA. Due to potentially significant differences in cultural dietary practices and National food fortification programs, research that reports the nutrition intake patterns and practices in Canadian youth athletes is needed, particularly in such a growing and popular sport as women’s soccer.
Purpose and Rationale of Study

The purpose of this study was to comprehensively describe and assess the nutrition and hydration status and practices of junior elite female soccer athletes. Understanding the status of these athletes will help to guide future research, develop age-appropriate sport-specific nutrition guidelines as well as inform professional practice.

Research Questions

- What is the immediate pre-training hydration status of junior elite female soccer players and what are the fluid and sweat sodium losses experienced during training?
- What are the current nutrition and hydration practices of junior elite female players?
- Are junior elite female soccer athletes meeting their hydration, energy, macronutrient and micronutrient needs to support growth and development as well as the demands of their sport?

Delimitations

The study was delimited to post menarcheal, female soccer athletes (14-18 years of age) on Metro and Super Y league teams (U15-U18 teams, Lower Island Soccer Association) training in Victoria, BC.

Limitations

1. The cross sectional study design is an inherent limitation to this study. Hydration assessment only occurred at two time points and self-reported nutrition intake over four days, therefore, it is difficult to extrapolate these results to be true indicators of typical practices throughout the year. In addition, this study was limited to a cross
sectional population of female elite soccer athletes between 14-17 years of age, who were post-menarcheal, playing on Vancouver Island. It is difficult to generalise results to all female adolescent soccer athletes in Canada.

2. Players were not blinded to hydration testing dates. Although athletes were encouraged to maintain their normal hydration practices, knowing they were to be tested may have influenced their hydration habits during testing days.

3. Food recording is known to have sources of error which include under or over reporting of intake, missing information due to respondent fatigue, as well as changes in usual intake as a result of having to record food (Bingham, 1985).

4. The nutrition/medical questionnaire used was not validated. The majority of data obtained from this questionnaire was used to report basic demographic information about participants.

5. Since this study sought to assess nutrition and hydration practices as they naturally occur during training, several aspects of the study could not be controlled. Factors such as environmental conditions, intensity of soccer training, training status of the athletes and menstrual phase were not controlled and could have impacted results.
Operational Definitions

**Soccer Training Session**: 90 minute on-field soccer training session fully conducted by coaches independent of the study, although coaches were aware that some players were involved in the study. Typical sessions involved warm up, soccer drills (sprinting, passing, shooting), small sided team games, group discussion and water breaks.

**Dietary Reference Intakes (DRI)**: a comprehensive set of nutrient reference values for Canadian and American healthy populations that can be used for assessing and planning diets (Otten, Hellwig & Meyers, 2006).

**Estimated Average Requirements (EAR)**: nutrient values used to assess the adequacy of nutrient intakes, as well as for the use of planning the intake of groups. The EAR represents the median daily intake value that is estimated to meet the requirement of half the healthy individuals in a life-stage and gender group. (Otten et al., 2006).

**Recommended Daily Allowances (RDA)**: the average daily dietary intake level that is sufficient to meet the nutrient requirement of nearly all (97-98%) healthy individuals in a particular life-stage and gender group. The values are used to represent usual intake by an individual (Otten et al., 2006).

**Adequate Intake (AI)**: nutrition reference ranges used if sufficient scientific evidence is not available to establish an EAR on which to base an RDA. The AI should meet or exceed the needs of most individuals in a specific life-stage and gender group (Otten et al., 2006).

**Acceptable Macronutrient Distribution Range (AMDR)**: a range of intake for a particular energy source (protein, fat, or carbohydrate), expressed as a percentage of total energy (kcal), that is associated with reduced risk of chronic disease while providing adequate intakes of essential nutrients (Otten et al., 2006).

**Upper Tolerable Intake (UL)**: The UL is the highest average daily nutrient intake level likely to pose no risk of adverse health effects to almost all individuals in a given life-stage and gender group (Otten et al., 2006).

**Macronutrients**: Energy (kilocalories), Carbohydrates(g), Protein(g), Fluids(ml), Fat(g)

**Micronutrients**: Vitamin A (ug), Vitamin B1 (mg), Vitamin B2 (mg), Niacin (mg), Vitamin B6 (mg) Folic Acid (ug), Vitamin C (mg), Vitamin D(ug), Vitamin E (mg), Calcium (mg) , Magnesium (mg), Zinc (mg), Iron (mg), Copper (mg), Selenium(mg), Phosphorus (mg), Potassium (mg), Sodium (mg)

**Nutritional Supplement**: Vitamins/minerals, sport bars, shakes, drinks (all carbohydrate and meal replacement drinks), herbal formulations or other ergogenic aids.
Chapter 2: Methods

Participants

A total of thirty-four female junior elite soccer athletes were recruited for this study. Participants were recruited from three different soccer teams within the Lower Island Soccer Association: U18 Metro team (n=6), U16 Metro team (n=12) and U15 Super Youth (Super Y) team (n=16). Metro and Super Y club soccer are two of the highest levels of competitive regional soccer for this age group, with a number of players also competing at the Provincial level.

All players trained at the same outdoor turf facility (Pacific Institute for Sport Excellence, PISE) in Victoria, BC, adjacent to the Canadian Sport Centre Pacific (CSCP) physiology laboratory in which all laboratory-based data were collected. Players were eligible to participate if they were post-menarcheal, between 14-18 years of age and devoid of injury that limited them from training with their respective team. With the assistance of team coaches, study investigators conducted an information and recruitment meeting with athletes and parents, describing all aspects of the study, and answering participant questions. Written informed consent was obtained from both participants and parents (Appendix B). Participation in the study was not a requirement of the team.

Institutional research ethics approval from the University of Victoria Human Research Ethics Board and the University of Victoria Biosafety Committee was obtained prior to participant recruitment.
Experimental Design

A descriptive, cross sectional research design was implemented. Data were collected over 12-weeks between March and June 2010. For each group of athletes recruited, data were collected over a 4 week time frame (Table 1). The Canadian Sport Centre Pacific (CSCP) physiology laboratory was used for all hydration and anthropometric data collection and analysis. Athletes were asked to complete a nutrition screening questionnaire, a 4-day food record as well as have blood work conducted at an external community-based blood laboratory setting within this 4 week time frame.

Table 1
Summary of 4-week Data Collection Protocol

<table>
<thead>
<tr>
<th>Time</th>
<th>Data Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visit 1 &amp; 2</td>
<td>Hydration Assessment:</td>
</tr>
<tr>
<td></td>
<td>• Fluid balance; Pre-training USG; Sweat sodium concentration; Heart rate</td>
</tr>
<tr>
<td>Visit 3</td>
<td>Anthropometric Assessment:</td>
</tr>
<tr>
<td></td>
<td>• Skinfolds</td>
</tr>
<tr>
<td></td>
<td>• Waist and hip girths</td>
</tr>
<tr>
<td></td>
<td>• Height and body weight</td>
</tr>
<tr>
<td>During 4 week testing period</td>
<td>• Blood collection and analysis</td>
</tr>
<tr>
<td></td>
<td>• 4-day food recording and medical/nutrition questionnaire</td>
</tr>
</tbody>
</table>

Hydration Status, Fluid Balance, Sweat Sodium Concentration and Exercise

Intensity Assessment Protocol

Participant hydration assessments were conducted during two typical, 90 minute training sessions (T1 and T2). All training sessions began at 18:30h. T1 and T2 measurements were separated by a minimum of 7 days and participants were encouraged to maintain normal hydration and nutrition habits throughout this period. Participants
reported to the lab for hydration assessment between 15-45 minutes before the training session.

Upon arrival, participants provided a mid-stream sample of urine into a labelled urine collection container within a private laboratory washroom. Urine samples were analyzed for urine specific gravity (USG) within 30 minutes of collection (PAL 10s Pocket Refractometer, ATAGO Tokyo, Japan). Pre-training body weight (nude) and personal hydration container/water bottle weight was recorded in a private in lab washroom (AND FG-150K scale, to the nearest 0.02kg). Type of beverage was recorded. All participants were instructed to drink only from their own water bottles and not to spit out fluid during training, or use it for any other purpose other than hydration. A sweat patch (Tegaderm + Pad, 3M Neuss, Germany) was applied to each of 5 regional sites and each participant was fitted with a heart rate monitor (Polar Team 2 version 1.1.0.3, Polar Systems USA).

Environmental conditions and a detailed description of the training sessions, including number of water breaks, and training activity were observed and recorded throughout each training session (Appendix E). If during soccer training participants needed to urinate/defecate during training, they were instructed to report to the lab in order to collect any urine voided.

Immediately post soccer training, participants reported directly to the lab where body weight (nude, towelling off excess sweat) and water bottle weight was recorded (to the nearest 0.02kg) and heart rate monitors removed. Each sweat patch was removed, placed into an individually labelled test tube, sealed and centrifuged within 30 minutes of
removal. Post centrifuge, sweat patch was removed from the test tube and the remaining sweat sample was refrigerated and analyzed within 24 hours of collection.

**Instruments**

**Hydration Status**

The urine specific gravity (USG) of pre-training urine samples was analyzed using a portable refractometer (PAL 10s Pocket Refractometer, ATAGO Tokyo, Japan). Using a three stage hypohydration protocol, Oppliger, Magnes, Popowski, & Gisolfi (2005) demonstrated that both USG and urine osmolality mimic acute changes in plasma osmolality, and USG is a viable tool for use in hydration status assessment. A USG value of >1.020 was used as an indicator of hypohydration status as per the National Athletic Trainers’ Association (NATA) Position Statement: Fluid Replacement for Athletes (Casa et al., 2000).

**Fluid Balance**

Acute change in body weight during exercise is a valid and widely used method to calculate sweat rate and hydration status (Sawka et al., 2007; Casa et al., 2000). Acute changes in weight during exercise have been shown to reflect the loss of body fluids through sweat and insensible evaporation (Oppliger & Bartok, 2002). Sweat rate (litres per hour) was estimated as net body mass loss (kilograms) during soccer (assuming 1 kg = 1 L) plus total fluid intake (litres) and minus any urine produced (litres) during training (hours).

\[
\text{Sweat rate} = (\text{Pre body mass - Post body mass}) + \text{Fluid intake} - \text{Urine output/Training time}
\]

Percent body mass was calculated as described by the equation:

\[
\text{Percent body mass loss} = \frac{\text{Pre body mass} - \text{Post body mass}}{\text{Pre body mass}} \times 100
\]

Body mass loss was not corrected for respiratory and metabolic water loss/gain.
**Sweat Sodium Concentration**

Sweat sodium concentration was determined using closed patch, regional sweat collection, a commonly used and valid method when assessing large numbers of participants in the field (Kilding et al., 2009; Maughan et al., 2005; Maughan et al., 2004). It has been previously shown that a strong, positive relationship exists between local patch collection across a variety of sites and whole body sweat composition, the gold standard criterion for sweat collection (Patterson, Galloway, Nimmo, & Baker, 2000; Baker, Stofan, Hamilton, & Horswill, 2009).

Using the protocol outlined by Patterson et al. (2000), absorbent sweat patches (Tegaderm + Pad, 3M Neuss, Germany) were applied to the skin at five sites on the right side of the body. The skin was washed thoroughly with water, cleaned with alcohol, washed again with water, and patted dry. Using precise anatomical landmarking ensured placement of the patches were identical during both T1 and T2 measures for each participant. The anatomical positions of the patch application sites were:

- chest (superior to the nipple and ~5cm lateral from the vertebral column),
- scapula (over the spine of the scapula and ~7cm lateral from the vertebral column),
- forearm (mid-dorsal),
- thigh (mid-ventral),
- lower back (~5cm lateral from the vertebral column).

Within 30 minutes of each training session, all patches were removed and placed in individually sealed, air tight, sterile test tubes and immediately centrifuged for one hour (Centrefuge Model 225A, Fisher Scientific Instruments, Dubque, Iowa). Post centrifuge, sweat patches were removed, and sweat samples were refrigerated. Analysis
of each sweat sample for sodium concentration was conducted in triplicate within 24 hours of collection using a conductivity analyzer (Wescor Sweat Chek 3120 Conductivity Analyzer, Logan, Utah). Sweat sodium levels have been previously demonstrated to be closely related to sweat chloride levels (Patterson et al., 2000; Baker, et al., 2009). Therefore the assumption was made that all sodium lost was that of sodium chloride.

For each participant, the ability to obtain sweat samples was inconsistent across the five regional sites. Since the low back sweat patch site has been previously reported to have a strong correlation coefficient ($r=0.88$) for analysis compared to whole body sweat sodium concentration Patterson et al. (2000), the low back sweat sodium concentration was chosen to be reported as the best representation of the sodium concentration in the participants. It has been well reported that local sweat patch collection over-estimates whole body sweat electrolyte losses by ~30-40%, likely due to a micro climate that is created when the patches are sealed around the skin potentially increasing local skin temperature (Palacios, Wigertz, & Weaver, 2003; Patterson et al., 2000; Baker et al., 2009). Thus, as has been performed in other studies, the values for sweat sodium concentrations reported in this study are adjusted by 35% to account for this overestimation (Kilding et al., 2009; Maughan et al., 2005; Maughan et al., 2004; Mao, Chen, & Ko, 2001).

In participants that provided samples from the chest, scapula, forearm and thigh regional sites, mean whole body sodium concentration (mmol/L) was calculated using the regression equation outlined by Patterson et al., (2000) where:

$$\text{Mean whole-body concentration} = 28.2\% \text{ chest} + 28.2\% \text{ scapula} + 11.3\% \text{ forearm} + 32.3\% \text{ thigh}$$
Sodium loss in grams (g) was also calculated by multiplying the sweat sodium concentration of the sweat samples (mmol/L) by the molecular weight of sodium and the total volume of sweat lost (ml) (Palmer & Spriet, 2008).

\[ \text{Sodium loss (g)} = (\text{sodium concentration} \times 22.99 \times \text{sweat loss}) \]

**Exercise Intensity**

Heart rate (HR) was measured throughout each training session at 5 second intervals using the Team 2 Polar Heart Rate Monitor System (Polar Team 2 version 1.1.0.3, Polar Systems USA). Mean heart rate (bpm) was calculated and percentage of predicted HR maximum (as determined by the predictive HR equation of 220-age; (Fox, Naughton, & Haskell, 1971) was calculated for each training session. Amount of time (hours: minutes: seconds) at different levels of relative intensity (determined by % HR max) was measured. Intensity levels (“zones”) were set as light (<35% HRmax), very light (35-54% HRmax), moderate (55-69% HRmax), hard (70-89% HRmax) and very hard (≥90%HRmax) following those outlined by the 1998 ACSM position stand: *The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults.* (Pollock et al., 1998). Intensity zones were then subcategorised as light (0-54% HRmax), moderate/hard (55-89% HRmax) and very hard (≥ 90%HRmax).

**Environmental Temperature**

Environmental conditions of ambient (dry) temperature and relative humidity (RH) were measured and recorded at 15 minute intervals throughout each training session with an on-field portable weather station (QuestTemp 36, Thermal Environmental Monitor, Quest Technologies). Mean temperature and RH were calculated and reported as means and standard deviations.
**Anthropometric, Nutrition and Hematological Assessment Protocol**

Anthropometric assessment was conducted before a training sessions on a day separate from those when hydration and sweat collection occurred. Over the four week testing period for each group, participants completed a nutrition screening questionnaire as well as a four day food record. Participants were familiarized with how to effectively record their food consumption (education regarding estimation of portion sizes using household measures) prior to beginning this process. Participants were then directed to record their detailed food intake for two training days, one rest day and one game day. (Appendix C). Hematological assessment was completed by participants at an external laboratory.

**Instruments**

**Anthropometric Measurement**

Anthropometric measures were collected using the restricted profile of the International Society for the Advancement of Kinanthropotery (Marfell-Jones, Olds, Stewart, & Carter, 2006). Height (Tanita HR 100 Stadiometer, to the nearest 0.5cm) and body mass (to the nearest 0.05kg) were measured on a digital scale (AND Digital Scale Model FG-150K, Island Scales, Victoria, Canada). Skinfold thickness (using Harpendin Skinfold Calipers to the nearest 0.1mm) at 8 sites (biceps, triceps, subscapular, iliac crest, supraspinale, abdominal, calf and thigh) as well as waist and gluteal girth measurements (using a Lufkin tape to the nearest 0.1cm) were taken. Body mass index (BMI) was determined using the formula: \( \text{BMI} = \frac{\text{body weight}}{\text{height}^2} \text{ (kg/m}^2\text{)}. \) Waist to hip ratio was determined by waist circumference (cm)/hip circumference (cm).
Energy Expenditure

Mean daily energy expenditure was calculated for the same four days used in food recording (rest day, 2 training days and one game day). This method allowed expenditure to be compared to intake and is similar to the protocol used by Caccialanza, Cameletti & Cavallaro (2007) who estimated mean energy expenditure in adolescent elite male soccer participants.

Daily estimated energy expenditure for the “rest day” (EER) was determined using the Dietary Reference Intake (DRI) predictive equation for female adolescents 9-18 years old (Otten, Hellwig & Meyers, 2006). A physical activity level (PAL) score of 1.5 was used which represents the mid range end of the “Low Active” physical activity coefficient values (1.4-1.59) and includes all typical daily living activities plus 30 - 60 minutes of daily moderate activity (ex. Walking 5-7km/hr).

Energy Expenditure on Rest days (EER; kcal)

\[ EER = 135.3 - (30.8 \times \text{age \[y\]) + 1.5 \times \{(10.0 \times \text{weight \[kg\]) + (934 \times \text{height \[m\])\) + 25} \]

EER was divided by 24 hours to determine an hourly kcal expenditure. Estimated energy expenditure for training (EET) and game day (EEG) was determined using the Compendium of Physical Activities by Ainsworth et al., (2000). Values for soccer training (7kcal/kg/hour – “soccer casual/general”) and soccer games (10kcal/kg/hour – “soccer competitive”) were used to calculate energy expenditure for 1.5 hours of activity. The EER for 22.5 hours was determined and the energy expenditure of training and game play was then added to this value.

Energy Expenditure on Training day (EET; kcals)

\[ = (EER/24\text{hours}) \times 22.5\text{hours} + (7\text{kcal/kg/hr \times kg body weight \times 1.5hrs}) \]
Energy Expenditure on Game day (EEG; kcals)

\[ \text{EEG} = \left( \frac{\text{EER}}{24\text{hours}} \right) \times 22.5\text{hours} + \left( 10\text{kcal/kg/hr} \times \text{kg body weight} \times \text{1.5hrs} \right) \]

Mean estimated energy expenditure was then determined using 2 training days, one game day and one rest day.

Mean Daily Energy Expenditure (MDEE; kcals)

\[ \text{MDEE} = \frac{\text{EER} + \text{EET} + \text{EET} + \text{EEG}}{4} \]

**Dietary Assessment**

Nutrition intake and dietary practices were assessed using a nutrition screening questionnaire as well as 4-day food records. The nutrition screening questionnaire is a non-validated tool which collected descriptive information related to health and menstrual history, food environment, daily activity as well as medication and dietary supplement intake history (Appendix C). In order to determine nutrition intake, 4 day estimated food records were completed by participants. Participants were requested to record time, description and quantity of all food, fluid and supplement intake for 4 different days (2 typical training days, 1 rest day and 1 competition day). All participants were encouraged to not to modify intake and received education from primary investigator, a Registered Dietitian, regarding determining portion sizes and estimation of household measures (ie. cups, ml, oz).

For the purpose of this experiment, participants used estimated methods for collection of information regarding dietary practice. While weighted methods (3-7 day) have been validated as the gold standard for the collection of dietary practices (Bingham, 1985), the main advantage of using estimated food records is that they involve less disruption to normal eating patterns than the weighing of food (Rutishauser, 2005). As a
result of this, one can obtain more accurate reflection of usual food habits (Rutishauser, 2005). Estimating rather than weighing the foods consumed leads to a loss of precision but the magnitude of this effect is not well documented (Rutishauser, 2005).

Analysis of food records was conducted using Food Processor Software (version 10.2.6, 2010, ESHA Research, Salem Oregon). Where possible, the 2007 Canadian Nutrient file database was used to retrieve food items. Missing nutrient data were retrieved from product manufactures websites and manually added to the nutrient totals. Mean dietary intake of total energy, carbohydrate, fibre, protein, fat, B vitamins (B1, B2, B3, Folate, B5, B6, B12), vitamins A, E, C, D, calcium, magnesium, phosphorus, copper, zinc and sodium were determined.

Macro and micronutrient results were compared to known Dietary Reference Intakes (DRIs) values [Estimated Average Requirements (EAR), and where EAR was not available, the Recommended Dietary Allowances (RDAs) and Adequate Intakes (AIs) were used] for females 14 -18 years old. Macronutrient results were compared to sport nutrition recommendations for adult female athletes (Burke et al., 2004; Tipton et al., Rodriguez, et al., 2009), as there are no recommended values available for female adolescent athletes. Multivitamin supplements as well as other micronutrient supplements were omitted from dietary analysis, in order for intake to be representative of food sources. Sport food supplements such as sport drinks, bars, or meal replacement products were included in dietary analysis.

**Hematological Assessment**

Blood samples were taken from participants by a trained phlebotomist at external community-based laboratory settings selected by each participant according to location
convenience. To control for exercise-induced influences on results, participants were asked to refrain from physical activity 24-hours before having their blood collection, and to present for this blood collection in a hydrated and fasted state. Samples were then analyzed for hematological profile (hemoglobin, hematocrit, RBC, WBC, platelet count and differentials), serum ferritin, total iron binding capacity (TIBC), transferrin saturation, 25-hydroxyvitamin D and pre-albumin at an accredited community based biomedical laboratory.

**Statistical Analysis**

The data were analyzed using SPSS (version 17.0, 2010, SPSS Inc., Chicago IL) software. All nutrition and hydration data are expressed as mean ± standard deviation (SD). Prior to data analysis, normality of distribution of data were tested by the Kolmogorov-Smirnov test (significance was set at $p \leq 0.05$) as well as normally distributed histogram.

Paired t-tests were used to test for significant differences between energy intake and energy expenditure, as well as differences between T1 and T2 for the training related dependant variables. These dependant variables included environmental conditions (temperature, relative humidity), exercise intensity (mean heart rate, time spent in each intensity zones) and hydration measures (sweat losses, fluid intake, percent body mass lost, USG, sweat sodium concentration). Where there were no significant differences found between T1 and T2, data for that variable were combined. Before all samples were combined, data were then tested for an age group main effect using one way ANOVA with Bonferroni correction. Mean intakes of micronutrients were compared to DRI
reference values and analyzed for significance differences using one sample t-tests \((p \leq 0.05)\).

Pearson’s product moment correlation analysis was used to quantify relationships between sweat rate and selected variables (USG, body mass, age, fluid intake, sweat sodium); sodium intake and sweat sodium; vitamin D intake and serum 25-hydroxyvitamin D; iron intake and serum ferritin; protein intake and serum prealbumin; and energy intake and serum prealbumin. Statistical significance was set at \(p \leq 0.05\).
Chapter 3: Results

Participant Characteristics

A total of 34 junior elite female soccer athletes participated in this study. All participants completed the hydration assessment, however due to scheduling conflicts, 2 participants (U18 group) completed only one hydration assessment and 3 (U16 group) completed their T2 assessment on a training day separate from their group peers (T2b). One participant withdrew from the study following her hydration assessment due to scheduling problems. As a result, 33 participants completed the anthropometric and nutrition assessment aspects of the study. A total of 28 participants completed the hematological analysis, with 5 participants choosing not to participate in this portion of the study due to reported fear of the blood test, or scheduling conflicts with other commitments.

Participant anthropometric characteristics and time spent in training are summarized in Table 2. Self reported estimated hours of sport training and competition (including school-based physical education) was 12.4 ± 5.1 hours per week. In addition to soccer training, a large proportion of participants (66.7%) reported participating in additional physical activity and competitive sport outside of soccer, including field hockey (12.1%), track and field (15.2%) and physical education classes in school (33.3%). Overall, athlete participants were healthy, post-menarcheal females with no self-reported significant chronic illness, injury or history of amenorrhea. A history of iron deficiency, which had been resolved clinically, was reported in 1 participant. The
incidence of self reported problems with muscle cramping was 39.4%, with the majority occurring in the calf or foot.

Table 2
Participant Anthropometric Characteristics and Self Reported Weekly Training Volume (n =33)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean ± SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>15.7 ± 0.7</td>
<td>14.6 - 17.3</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>60.9 ± 8.2</td>
<td>48.4 - 76.2</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>163.8 ± 5.9</td>
<td>150.7 - 179.7</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.7 ± 2.7</td>
<td>18.3 - 29.0</td>
</tr>
<tr>
<td>Sum of 7 Skinfolds (mm)*</td>
<td>103.1 ± 35.2</td>
<td>46.5 - 181.5</td>
</tr>
<tr>
<td>% Body Fat **</td>
<td>20.2 ± 5.4</td>
<td>11.0 - 29.9</td>
</tr>
<tr>
<td>Waist to Hip Ratio***</td>
<td>0.77 ± 0.04</td>
<td>0.69 - 0.87</td>
</tr>
<tr>
<td>Training (hrs/week)</td>
<td>12.4 ± 5.1</td>
<td>4.5 - 23.5</td>
</tr>
</tbody>
</table>

* Skinfold sites: biceps, triceps, subscapular, front thigh, calf, supraspinale, abdominal
** Body fat based on the equation of Withers et al, (1987) for female athletes
*** Waist and hip measures based on only 30 participant measurements

Characteristics of Soccer Training Sessions

The mean environmental conditions for each training session are summarised in Table 3. T1 sessions were generally cooler than T2 sessions, and within the U16 group, T1 temperature was significantly lower than T2 and T2b temperatures (p ≤ 0.05). In the U15 group, T1 temperature was significantly lower than T2 (p ≤ 0.05).
Table 3:

Environmental Conditions for Soccer Training Sessions (Mean ± SD)

<table>
<thead>
<tr>
<th>Group</th>
<th>Training Session</th>
<th>N</th>
<th>Mean Ambient Temperature (°C)</th>
<th>Mean Relative Humidity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U18</td>
<td>T1</td>
<td>5</td>
<td>6.1 ± 0.9</td>
<td>78.6 ± 17.4</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>5</td>
<td>6.2 ± 0.4</td>
<td>67.0 ± 13.0</td>
</tr>
<tr>
<td>U16</td>
<td>T1</td>
<td>12</td>
<td>8.8 ± 1.2*†</td>
<td>60.8 ± 11.1</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>9</td>
<td>12.4 ± 1.6</td>
<td>59.3 ± 10.9</td>
</tr>
<tr>
<td></td>
<td>T2b</td>
<td>3</td>
<td>12.3 ± 1.8</td>
<td>68.1 ± 13.6</td>
</tr>
<tr>
<td>U15</td>
<td>T1</td>
<td>16</td>
<td>8.0 ± 0.9*</td>
<td>59.0 ± 11.5</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>16</td>
<td>14.6 ± 0.9</td>
<td>57.9 ± 6.6</td>
</tr>
</tbody>
</table>

Where * = T1 statistically different to T2, p ≤ 0.05
Where † = T1 statistically different to T2b, p ≤ 0.05

Training session intensity, as determined by mean heart rate, mean percentage heart rate max (%HRmax) and mean time spent at differing levels of relative intensity, was combined for T1 and T2 sessions and are provided in Table 4. In the U15 group, heart rate and %HRmax were significantly higher in T1 (148 ± 7 bpm and 72%) when compared to T2 (141 ± 6 bpm and 68%) (p ≤ 0.05). The U15 group spent significantly more time in the relative intensity zones of “Light” (24:21 ± 8:52 min) and “Very Hard” (18:40± 9:25 min) in T1 compared to the T2 training session [Light (01:11± 1:30 min), very hard (7:19 ± 4:18 min)] (p ≤ 0.05) and significantly less time in “Mod/Hard” (48:27 ± 8:32min) zone in T1 compared to Mod/Hard zone in T2 (1:13:25 ± 24:11 min) (p ≤ 0.05). This difference is likely due to differences in training sessions, as the U15 T1 training included more high intensity shuttle running drills and a longer short sided team
game. In addition, T1 was the first training session of the season for the team and players were adjusting to a new training session routine with a new coach.

Table 4

Heart Rate (bpm), Percent HR Max and Time (minutes) Spent at Differing Levels of Intensity During Soccer Training Sessions (Mean ± SD)

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean HR (bpm)</th>
<th>% HR max</th>
<th>Light Intensity(mins)</th>
<th>Mod/hard Intensity(mins)</th>
<th>V.hard Intensity (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U18</td>
<td>10</td>
<td>141 ± 8</td>
<td>70 ± 4</td>
<td>30:15 ± 9:18</td>
<td>44:45 ± 5:20</td>
<td>10:13 ± 7:26</td>
</tr>
<tr>
<td>U16</td>
<td>24</td>
<td>132 ± 8</td>
<td>65 ± 4</td>
<td>47:06 ± 11:35</td>
<td>35:04 ± 10:40</td>
<td>8:18 ± 5:39</td>
</tr>
<tr>
<td>All Groups</td>
<td>66</td>
<td>140 ± 9</td>
<td>68 ± 5</td>
<td>30:43 ± 18:51</td>
<td>49:49 ± 19:38</td>
<td>11:08 ± 8:15</td>
</tr>
</tbody>
</table>

Relationships Between Ambient Temperature, Exercise Intensity and Hydration Measures

When all group samples were combined, there were no significant correlations found between ambient temperature and the hydration measures of fluid intake ($r = -0.279$, $p = 0.72$) sweat loss ($r = -0.281$, $p = 0.51$), percent body mass loss ($r = -0.251$, $p=0.18$), USG ($r = 0.83$, $p=0.573$), or sweat sodium concentration ($r = -0.207$, $p=0.311$) ($p > 0.05$). No significant correlations were found in any intensity zone and hydration measures ($p > 0.05$). In addition, there were no significant correlations between mean heart rate and % heart rate max and any hydration measures ($p > 0.05$).
Pre-Training Hydration Status

Figure 1 outlines the mean USG measures for each team group (T1 and T2 data combined) as well as the overall all samples combined USG. The combined group mean pre-training USG was 1.018 ± 0.009 (range = 1.003-1.034) and encompassed 66 player measurements (33 players, T1 and T2). The mean USG indicates that this group of athletes arrived to training being very close to hypohydrated state. When individual data were examined 30 (45.4%) players presented to training with a USG >1.020, which placed them in a recognized hypohydrated state. Of those players deemed hypohydrated, 11 (16.7%) players arrived to training with USG between 1.020 - 1.024, 16 (24.2%) players with USG between 1.025 -1.029, and 3 (4.5%) players with a USG >1.030. There were no significant differences in USG between T1 and T2 measures or between groups (p > 0.05).

**USG >1.020 indicates mild hypohydration.

Figure 1. Pre training urine specific gravity (USG) by age group and combined together (Mean ± SD)
Training Induced Body Mass Changes, Fluid Intake and Sweat Rate

Table 5 provides the mean body mass changes, fluid intake and sweat rate for each training group and all samples combined, representing 66 player measurements. There were no significant differences in percentage body mass loss, fluid intake, total sweat loss or sweat rate between T1 and T2 measures or between groups, therefore all samples were combined (p ≤ 0.05). No player voided any urine/feces during the training sessions.

The mean percent body mass loss for all samples combined was 0.84% ± 0.07% (range = -0.28 % – 5.21%). When considering individual data, 6 (9.1%) players lost between 1-2% of their body mass and 8 players (12.1%) lost over 2% of their body mass during the training session. The mean sweat loss was 688.3 ± 427.4 ml and sweat rate was 458.8 ± 284.9 ml/hour with a large range of 26.7-1866.5 ml/hour. The mean fluid intake during the training sessions was 195 ± 0.2 ml with a wide range of fluid consumption measured (0 - 600ml). Over the 90 minute training session, all players (100%) drank less than 1 litre of fluid, with 42 (63.6%) drinking less than 250ml and 20 (30.3%) drinking between 250-500ml. Observed beverages used during training sessions revealed the majority of players (97.0%) consumed water with only one participant using diluted sport drink as their fluid choice during both training sessions. When considering fluid intake versus loss, players, on average were able to replenish ~90% of losses (range = 8-650%) as indicated by their post-training session body weight and their respective sweat loss.
Table 5

Participant Body Mass Changes, Fluid Consumption and Sweat Loss During Soccer Training Sessions (Mean ± SD)

<table>
<thead>
<tr>
<th>Group</th>
<th>n *</th>
<th>Body Mass Pre (kg)</th>
<th>Body Mass Post (kg)</th>
<th>% Body Mass Lost</th>
<th>Fluid Intake (ml)</th>
<th>Total Sweat Lost (ml)</th>
<th>Sweat Rate (ml/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U18</td>
<td>12</td>
<td>62.6 ± 5.7</td>
<td>62.2 ± 5.7</td>
<td>0.51 ± 0.25</td>
<td>140.0 ± 117.4</td>
<td>458.0 ± 48.0</td>
<td>305.3 ± 32.0</td>
</tr>
<tr>
<td>U16</td>
<td>24</td>
<td>60.7 ± 7.0</td>
<td>60.5 ± 7.0</td>
<td>0.50 ± 0.27</td>
<td>145.8 ± 153.6</td>
<td>451.2 ± 138.7</td>
<td>300.8 ± 92.4</td>
</tr>
<tr>
<td>U15</td>
<td>32</td>
<td>61.1 ± 9.8</td>
<td>60.4 ± 9.8</td>
<td>1.19 ± 0.69</td>
<td>249.4 ± 162.2</td>
<td>938.1 ± 427.4</td>
<td>625.3 ± 284.9</td>
</tr>
<tr>
<td>All Samples Combined</td>
<td>66</td>
<td>61.1 ± 9.8</td>
<td>60.7 ± 9.8</td>
<td>0.84 ± 0.69</td>
<td>195.9 ± 0.2</td>
<td>688.3 ± 427.4</td>
<td>458.8 ± 284.9</td>
</tr>
</tbody>
</table>

*(T1 and T2 Sessions Combined)*

Self Reported Fluid Intake Practices

Self reported fluid intake practices, as determined by the nutrition questionnaire, revealed pre-training (~2 hours before) mean intake of 398 ± 318 ml, during training intake of 420 ± 277 ml and post training (~60mins post training) of 418 ± 315ml. The majority of participants cited water as the primary beverage used. Water (84.8%), juice (18.2%), milk (9.1%) and sport drink (6.1%) were cited as beverages used before training, water (100%) and sport drink (6.1%) during training, and water (84.8%), chocolate milk (15.1%) and sport drink (15.1%) cited as post training beverages.

Training Induced Sweat Sodium Concentration

There was no significant difference in sweat sodium concentration between T1 and T2 measures for each age group or between age groups (p > 0.05). Sweat sodium data were therefore combined and presented in Table 6. The ability to obtain sweat
samples was inconsistent across the five regional sites. Of the 66 samples taken at each site (33 participants, T1 and T2), the low back (74.2%) and scapula (65.2%) regional sites provided the greatest number of measureable sweat samples. Since the low back sweat patch site yielded the highest number of measurable samples and this regional site has been previously reported to have a strong correlation coefficient ($r=0.88$) for analysis compared to whole body sweat sodium concentration (Patterson et al., 2000), the low back sweat sodium concentration was chosen to be reported as the best representation of the sweat sodium concentration in the participants. Mean sweat sodium concentration from this site therefore was $47.6 \pm 11.9$ mmol/L, with a corrected value of 31mmol/L or 1.9g of sodium

Table 6

*Sweat Sodium Concentration Across Different Regional Sites (Mean ± SD)*

<table>
<thead>
<tr>
<th>Regional Site</th>
<th>No. Samples Retrieved From Regional Site</th>
<th>Mean Na+ concentration (mmol/L)</th>
<th>Corrected Na+ concentration (mmol/L)</th>
<th>Sweat Sodium Loss (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Back</td>
<td>49</td>
<td>$47.6 \pm 11.9$</td>
<td>31</td>
<td>1.9</td>
</tr>
<tr>
<td>Forearm</td>
<td>17</td>
<td>$51.3 \pm 8.6$</td>
<td>33</td>
<td>2.1</td>
</tr>
<tr>
<td>Scapula</td>
<td>43</td>
<td>$61.2 \pm 15.6$</td>
<td>39</td>
<td>2.5</td>
</tr>
<tr>
<td>Chest</td>
<td>31</td>
<td>$55.1 \pm 15.3$</td>
<td>36</td>
<td>2.3</td>
</tr>
<tr>
<td>Thigh</td>
<td>33</td>
<td>$59.8 \pm 9.9$</td>
<td>39</td>
<td>2.4</td>
</tr>
</tbody>
</table>

*Relationships Between USG, Fluid loss, Fluid Intake and Sweat Sodium Measures*

Despite the minor significant differences in environmental temperatures, heart rate and relative intensity, no significant differences were seen in pre-training USG, sweat loss, fluid intake or sweat sodium concentration between training sessions or age
groups. All hydration samples were therefore combined before exploring relationships between specific measures. No significant correlations were found between sweat rate and USG (r=0.011, p=0.930), body mass (r=0.012, p=0.963), age (r=0.109, p=0.930), fluid intake (r=0.279, p=0.023), or low back sodium loss (r=0.382, p=0.072).

**Energy Balance**

Table 7 outlines energy balance of participants. Mean daily energy intake was significantly lower than mean estimated energy expenditure (p ≤ 0.05). The average estimated energy deficiency was 461 ± 548 kcal/day. Only 7 (21.2%) participants reported the consumption of what would be adequate energy in order to meet their estimated energy requirements. Specifically, the mean relative energy intake was 35.2 ± 9.8 kcal/kg which was significantly (p ≤ 0.05) lower than suggested range of 47 - 60 kcal/kg for adult female soccer players of (Martin et al., 2006).
Table 7

*Estimated Energy Expenditure (EEE) and Energy Intake of Participants Relative to Common Recommendations (n = 33) (Mean ± SD)*

<table>
<thead>
<tr>
<th></th>
<th>Mean ± SD</th>
<th>Range</th>
<th>% Participants consuming &lt; Reference Intake (n)</th>
<th>Reference Intake</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy Expenditure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EER (rest)</td>
<td>2131 ± 124</td>
<td>1953-2385</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>EET (train)</td>
<td>2637 ± 202</td>
<td>2345-3029</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>EEG (game)</td>
<td>2911 ± 239</td>
<td>2562-3369</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean EE</td>
<td>2546 ± 190</td>
<td>2272-2916</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Energy Intake</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kcal/d</td>
<td>2079 ± 460</td>
<td>1292-3231</td>
<td>78.8 (26)</td>
<td>2630 ±192 a</td>
</tr>
<tr>
<td>kcal/kg</td>
<td>35.2 ± 9.8</td>
<td>21.1-60.3</td>
<td>84.5 (28)</td>
<td>47-60 b</td>
</tr>
</tbody>
</table>

*a Dietary Reference Intakes: Equations to estimate energy requirement (Females 9-18years old) (Otten, Hellwig & Meyers, 2006).

*b Martin et al., 2006

**Macronutrient Intake**

Table 8 describes the mean macronutrient intake of the participants compared to Canadian Dietary Reference Intakes (DRIs) for females 14-18 years of age, as well as adult sport nutrition recommendations. The mean macronutrient distribution was found to be comprised of 56.1% carbohydrate, 16.1% protein and 29.9% fat which falls within normal ranges of the Acceptable Macronutrient Distribution Ranges (AMDR) for Canadian female adolescents 14-18 years old (Otten, Hellwig & Meyers, 2006). Saturated fat intake was 10.1 ± 2.6% of total energy and within AMDR recommended ranges (Otten, Hellwig & Meyers, 2006). Mean fibre intake was within Adequate Intake (AI) recommendations, however a large proportion of individuals, 25 (75.8%), fell below the recommended AI for fibre (Otten, Hellwig & Meyers, 2006). Self reported intake of fluids within food records had large inter-individual variability, with several athletes...
failing to consistently report fluids. As a result, mean daily total fluid intake is not reported.

Mean macronutrient intake relative to body weight was $5.0 \pm 1.6 \text{g/kg}$ and $1.4\text{g/kg}$ for carbohydrate and protein respectively. Compared to adult sport nutrition recommendations for carbohydrate which suggest a minimum intake of $5\text{g/kg}$ for female participants, mean intake was appropriate, however 17 (51.5%) individual participants consumed less than the recommended $5\text{g/kg}$ (Burke, Kiens, & Ivy, 2004).

Mean protein intake was determined to be 1.4 g/kg, with all participants meeting the protein intake recommendations when compared to the DRI Estimated Average Requirement (EAR) value (Otten, Hellwig & Meyers, 2006), as well as sport nutrition recommendations of $1.2\text{g/kg/day}$ (Tipton & Wolfe, 2004). However, when individual data were examined closely it was found that 9 (27.3%) participants consumed less than $1.2\text{g/kg/day}$. 
Table 8

Macronutrient Intake of Participants and the Proportion of Participants Not Meeting Dietary Reference Intakes (DRI’s) and Sport Nutrition Recommendations (n = 33) (Mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>Mean ± SD</th>
<th>Range</th>
<th>% Participants consuming &lt; Reference Intake (n)</th>
<th>Reference Intake</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carbohydrate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total g</td>
<td>293.8 ± 84.8</td>
<td>143.0 - 533.6</td>
<td>0 (0)</td>
<td>100g (^a)</td>
</tr>
<tr>
<td>Fibre g</td>
<td>22.6 ± 19.6</td>
<td>11.0 - 38.0</td>
<td>75.8 (25)</td>
<td>26 g/d (^b)</td>
</tr>
<tr>
<td>% Total Energy Intake</td>
<td>56.1 ± 7.9</td>
<td>38.0 - 67.7</td>
<td>6.1 (2)</td>
<td>45 - 65(^c)</td>
</tr>
<tr>
<td>g/kg</td>
<td>5.0 ± 1.6</td>
<td>2.0 - 9.9</td>
<td>51.5 (17)</td>
<td>5 - 7g/kg/day (^d)</td>
</tr>
<tr>
<td><strong>Protein</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g</td>
<td>82.2 ± 19.1</td>
<td>44.6 - 122.2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>% Total Energy Intake</td>
<td>16.1 ± 3.3</td>
<td>9.5 - 25.3</td>
<td>3.3 (1)</td>
<td>10 - 30(^c)</td>
</tr>
<tr>
<td>g/kg</td>
<td>1.38 ± 0.3</td>
<td>0.8 - 2.3</td>
<td>27.3 (9)</td>
<td>1.2g/kg/day (^e)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0 (0)</td>
</tr>
<tr>
<td><strong>Fat</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g</td>
<td>68.9 ± 19.6</td>
<td>36.1 - 112.4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>% Total Energy Intake</td>
<td>29.9 ± 5.8</td>
<td>20.6 - 41.7</td>
<td>21.2 (7)</td>
<td>25 - 35(^c)</td>
</tr>
<tr>
<td>% Saturated Fat</td>
<td>10.1 ± 2.6</td>
<td>6.1 - 16.7</td>
<td>36.4 (12)</td>
<td>&lt;10% total energy (^c)</td>
</tr>
<tr>
<td>g/kg</td>
<td>1.2 ± 0.4</td>
<td>0.60 - 2.3</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

\(^a\) DRI’s: Estimated Average Requirement (Otten, Hellwig & Meyers, 2006).
\(^b\) DRI’s: Adequate Intake (Otten, Hellwig & Meyers, 2006).
\(^c\) DRI’s: Acceptable Macronutrient Distribution Range (Otten, Hellwig & Meyers, 2006).

Micronutrient Intake

Table 9 describes the micronutrient intake by participants compared to the applicable DRI values (Estimated average requirements (EAR), Recommended Daily Allowance (RDA), Adequate Intake (AI)) for females, 14 – 18 years old. For the majority of micronutrients, mean intake exceeded DRI recommendations. However, mean intake of pantothenic acid and vitamin D were below DRI recommendations although not statistically different than the DRI values (p > 0.05). Mean intake for folate, vitamin E
and calcium were significantly below the DRI recommendations (p ≤ 0.05).

Although the mean micronutrient intake suggests that for most participants, their diets were adequate, many individuals failed to meet recommendations for a variety of nutrients. A substantial proportion of participants did not meet their EAR or AI for magnesium (47.5%), phosphorus (27.3%), vitamin A (27.3%), vitamin B12 (21.2%) and zinc (21.2%). Intake of vitamin B1 (12.1%), vitamin B2 (6.1%), niacin (18.2%), B6 (15.1%), vitamin C (15.2%), iron (6.1%) and copper (3.0%) were below their DRI values in a smaller proportion of participants.

Mean intake for sodium was 3075.6 ± 935.8mg, which statistically significantly exceeds the AI range by 205.0% ± 62.4% and the Upper Tolerable Intake by 133.7% ± 40.7% (Otten, Hellwig & Meyers, 2006) (p ≤ 0.05).

**Relationship Between Sodium Intake an Sweat Sodium Concentration**

The relationship between sweat sodium concentration and dietary sodium intake revealed no significant correlations, for any regional site, chest (r = -0.091, p = 0.365), forearm (r = 0.733, p = 0.049), thigh (r = -0.016, p = 0.482), scapula (r = -0.138, p = 0.270) and low back (r = 0.170, p = 0.219).
### Table 9

**Dietary Intake of Micronutrients Relative To Dietary Reference Intakes (DRIs) Recommendations (n =33) (Mean ± SD)**

<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>Mean Intake (n)</th>
<th>Mean Intake % DRI</th>
<th>% below RDA/AI (n)</th>
<th>% below EAR (n)</th>
<th>DRI*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin B1 (mg/d)</td>
<td>1.7 ± 0.8</td>
<td>186.7 ± 89.3</td>
<td>-</td>
<td>12.1 (4)</td>
<td>0.9</td>
</tr>
<tr>
<td>Vitamin B2 (mg/d)</td>
<td>1.8 ± 0.6</td>
<td>195.8 ± 68.3</td>
<td>-</td>
<td>6.1 (2)</td>
<td>0.9</td>
</tr>
<tr>
<td>Niacin (mg/d)</td>
<td>17.7 ± 5.4</td>
<td>156.6 ± 48.9</td>
<td>-</td>
<td>18.2 (6)</td>
<td>11</td>
</tr>
<tr>
<td>Pantothenic acid (mg/d)</td>
<td>4.7 ± 1.6</td>
<td>94.1 ± 32.4</td>
<td>54.5 (18)</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Vitamin B6 (mg/d)</td>
<td>1.7 ± 0.6</td>
<td>166.9 ± 58.7</td>
<td>-</td>
<td>15.1 (5)</td>
<td>1.0</td>
</tr>
<tr>
<td>Vitamin B12 (µg/d)</td>
<td>3.1 ± 1.1</td>
<td>152.5 ± 55.1</td>
<td>-</td>
<td>21.2 (7)</td>
<td>2.0</td>
</tr>
<tr>
<td>Folate (µg/d)</td>
<td>273 ± 94.9</td>
<td>82.9 ± 28.7**</td>
<td>-</td>
<td>69.7 (23)</td>
<td>330</td>
</tr>
<tr>
<td>Vitamin A (µg/d)</td>
<td>713.9 ± 343.4</td>
<td>147.2 ± 70.8</td>
<td>-</td>
<td>27.3 (9)</td>
<td>485</td>
</tr>
<tr>
<td>Vitamin D (µg/d)</td>
<td>2.4 ± 0.4</td>
<td>81.6 ± 47.4</td>
<td>69.7 (23)</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Vitamin C (mg/d)</td>
<td>79.6 ± 29.6</td>
<td>251.3 ± 142.1</td>
<td>-</td>
<td>15.2 (5)</td>
<td>56</td>
</tr>
<tr>
<td>Vitamin E (mg/d)</td>
<td>5.3 ± 2.5</td>
<td>44.2 ± 21.2**</td>
<td>-</td>
<td>100 (33)</td>
<td>12</td>
</tr>
<tr>
<td>Calcium (mg/d)</td>
<td>931 ± 351.1</td>
<td>71.6 ± 21.0**</td>
<td>90.9 (30)</td>
<td>N/A</td>
<td>1300</td>
</tr>
<tr>
<td>Phosphorus (mg/d)</td>
<td>1237 ± 374.6</td>
<td>117.3 ± 35.5</td>
<td>-</td>
<td>27.3 (9)</td>
<td>1055</td>
</tr>
<tr>
<td>Magnesium (mg/d)</td>
<td>303.8 ± 111.3</td>
<td>101.3 ± 37.1</td>
<td>-</td>
<td>47.5 (16)</td>
<td>300</td>
</tr>
<tr>
<td>Iron (mg/d)</td>
<td>16.2 ± 5.9</td>
<td>205.0 ± 74.3</td>
<td>-</td>
<td>6.1 (2)</td>
<td>7.9</td>
</tr>
<tr>
<td>Zinc (mg/d)</td>
<td>9.5 ± 2.9</td>
<td>129.9 ± 40.3</td>
<td>-</td>
<td>21.2 (7)</td>
<td>7.3</td>
</tr>
<tr>
<td>Copper (µg/d)</td>
<td>1399.7 ± 469.0</td>
<td>204.3 ± 68.5</td>
<td>-</td>
<td>3.0 (1)</td>
<td>685</td>
</tr>
</tbody>
</table>

*DRIs. Females 14–18 years old (Otten, Hellwig & Meyers, 2006).

** = mean intake statistically significantly lower than DRI, p ≤ 0.05
**Nutrition Practices**

Nutrition screening questionnaire results revealed that five participants (15.2%) had special dietary practices including Kosher eating, peanut allergy and lactose intolerance. No participants identified themselves as vegetarian. All participants reported that they did not shop for or prepare their own meals. Three participants (9.1%) reported having worked with a nutrition professional such as a Registered Dietitian in the past. Very few participants reported using dietary supplements on a regular basis, although those that did included vitamin D (n=1), multivitamins (n=2), a herbal cold/flu remedy (n=1) and an fatty acid supplement (n=1).

**Hematological Assessment**

Mean serum hematological parameters are described in Table 10 and Table 11 and are compared to clinical reference values (LifeLabs Inc). Due to limitations with blood analysis, total iron binding capacity (TIBC), transferrin saturation, and plasma iron level were analyzed in only 16 participants, while pre-albumin status was assessed in only 23 participants. The mean values for all iron and protein status parameters measured were within normal reference ranges, with a small proportion of individual participants below the reference values for hemoglobin (3.6%) hematocrit (3.6%), RBC (7.1%), WBC (3.6%), serum ferritin (7.1%) and transferrin saturation (25%).
Table 10

Hematological Parameters of Iron Related Indices, Vitamin D and Pre-albumin of Study Participants (n = 28) (Mean ± SD)

<table>
<thead>
<tr>
<th>Hematological Parameter</th>
<th>Mean ± SD. Combined</th>
<th>% below normal range (n)</th>
<th>Reference Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemoglobin (g/L)</td>
<td>130.2 ± 8.1</td>
<td>3.6 (1)***</td>
<td>117 - 149</td>
</tr>
<tr>
<td>Hematocrit</td>
<td>0.39 ± 0.02</td>
<td>3.6 (1)***</td>
<td>0.35 - 0.44</td>
</tr>
<tr>
<td>RBC (Tera/L)</td>
<td>4.36 ± 0.29</td>
<td>7.1 (2)***</td>
<td>4.00 - 4.87</td>
</tr>
<tr>
<td>WBC (giga/L)</td>
<td>6.5 ± 1.7</td>
<td>3.6 (1)***</td>
<td>3.9 - 10.2</td>
</tr>
<tr>
<td>Serum ferritin (ug/L)</td>
<td>22.5 ± 9.2</td>
<td>7.1 (2)***</td>
<td>12 - 83</td>
</tr>
<tr>
<td>25-hydroxyvitamin D (nmol/L)</td>
<td>75.4 ± 18.5</td>
<td>0</td>
<td>25 - 135</td>
</tr>
<tr>
<td>Pre-albumin (mg/L)**</td>
<td>261.8 ± 26.5</td>
<td>0</td>
<td>150 - 360</td>
</tr>
</tbody>
</table>

*Source: LifeLabs Incorporated

** Pre-albumin was available for 23 participants.
*** One participant alone had abnormal hemoglobin, hematocrit, RBC, WBC and serum ferritin values

Table 11

Total Iron Binding capacity (TIBC), Transferrin Saturation and Plasma Iron Levels of Study Participants (n = 16) (Mean ± SD)

<table>
<thead>
<tr>
<th>Hematological Parameter</th>
<th>Mean ± SD. Combined</th>
<th>% below normal range (n)</th>
<th>Reference Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIBC (umol/L)</td>
<td>59.6 ± 9.9</td>
<td>0 (0)</td>
<td>32 - 72</td>
</tr>
<tr>
<td>Transferrin saturation (%)</td>
<td>0.28 ± 0.10</td>
<td>25 (4)</td>
<td>0.2 - 0.55</td>
</tr>
<tr>
<td>Plasma Iron (ug/L)</td>
<td>17.8 ± 7.0</td>
<td>6.2 (1)</td>
<td>10 - 33</td>
</tr>
</tbody>
</table>

*Source: LifeLabs Incorporated

Relationships Between Nutrition and Hematological Variables
There were no significant correlations between dietary iron intake and serum ferritin, \((r=0.120, p=0.552)\), dietary vitamin D intake and 25-hydroxyvitamin D (nmol/L) \((r=0.125, p=0.536)\), dietary protein intake and pre albumin \((r=-0.443, p=0.037)\) or dietary energy intake and pre albumin \((r=0.82, p=0.373)\).
Chapter 4: Discussion

The present study is the first comprehensive assessment of both the nutrition and hydration status and practise of junior Canadian elite female soccer athletes. The adolescent female athlete is faced with the dual challenge of meeting not only nutrition and hydration demands for growth and development, but also those to support athletic performance. The findings of this study identify and define important nutrition and hydration inadequacies within the female soccer athlete population.

For the purpose of the following discussion, results are reviewed and compared to adult, athletic and non-athletic adolescent nutrition and hydration recommendations, as well as to the available literature conducted in soccer. Unfortunately, very little research and recommendations specific to the young female athlete are currently available. It is not known for example, if the DRI’s for healthy non-athletic female adolescents are appropriate for athletes, or if current adult sport nutrition guidelines for carbohydrate and protein recommendations are applicable. Although there is a paucity of research in female youth player on which to compare our research, the results from this novel investigation can be used to inform innovative, population specific sport nutrition guidelines.

Anthropometrics

Comprehensive assessment of physique traits in female junior elite soccer athletes is scarce within the literature. Ideal physique traits and anthropometric characteristics for adolescent female soccer athletes have not been established, however compared to available literature, participants within this study appear to be within similar ranges to
adult, elite female players (Mullinix et al., 2003; Clark et al., 2003).

Heaney et al. (2010) profiled 72 elite female athletes (including adolescents) across a variety of sports using the same ISAK skinfold protocol and Withers equation for estimation of body fat as the present study. Participants in this current study had comparable mean sum of seven skinfolds and body fat to the elite female team sport athletes (netball, softball and volleyball) (Heaney, O’Conner, Gifford, & Naughton, 2010). Conversely, lower mean body fat levels of 16.4 (± 2.4%) and 17.5 (± 7.3%) respectively have been reported in young (11-14 year old) female endurance team athletes (De Sousa, Da Costa, Nogueira, & Vivaldi, 2007) as well as in 14 adult NCAA female soccer athletes (Clark et al., 2003). These differences may be explained by the methodologies used: Clarke et al., estimated body fat using hydrostatic weighing and DeSousa et al., employed a two skinfold site equation. These methodological differences in body fat estimation makes comparison of results difficult.

The BMI of participants in the present study was 22.7 ± 2.7 which is similar that reported in adult female soccer athletes by Mullinix et al. (2003) and Martin et al. (2006). A slightly lower BMI (19.2 ± 2.7) was reported by De Sousa et al., (2007) in 47 female athletes from mixed sports, which included soccer, handball and basketball athletes, however their athletes were younger than athletes in the present study and pubertal development could have impacted body weight. Although BMI is often reported in athlete literature and is the recommended screening tool for overweight and obesity in children, adolescents and adults (Otten et al., 2006), its use in athletes has been shown to classify more muscular individuals with low skinfold measurements as overweight (Witt, Edwin & Bush, 2005).
Another measure commonly used as an indicator of body fatness and disease risk is the Waist/Hip Ratio (WHR) (Otten et al., 2006). WHR of less than 0.8 for women indicates a low risk classification. Although no similar values for health risk are available for adolescent females, the WHR for participants in this study was 0.77 (± 0.04), which would be expected in an active, healthy female athlete population.

Pre-Training Hydration Status

This is the first study to describe pre-training hydration status of adolescent female elite soccer athletes. Urine specific gravity (USG) has been previously demonstrated as a viable tool in the assessment of hydration status of athletes (Oppliger et al., 2005), with a value of >1.020 used as an indicator of hypohydration (Casa et al., 2000). The mean pre-training USG results of this study suggest that most players were mildly hypohydrated (1.018 ± 0.009). An important finding of this study was the observation that almost half (45.4%) of the players presented to training in a hypohydrated state (USG >1.020). The large between-subject variability for USG values (ranging from 1.003-1.034) provides evidence to suggest that athlete’s pre-training hydration practices were less than optimal.

A summary of literature reporting the pre-training USG and urine osmolarity of adult male and female soccer athletes is found in Table 11. The present study’s USG values are higher than those reported by Kilding et al., (2009) who assessed pre-training USG in 13 adult female elite soccer athletes before two training sessions in similar environmental temperatures and time of day. USG values from the present study are similar and slightly lower than those found in adult male soccer athletes (Maughan et al., 2004, 2005) as well as in adolescent male hockey (Palmer & Spreit, 2008) and football.
athletes (Stover, Zacheiejaj, Sofan, Murray, & Horswill, 2006).

Pre-exercise hypohydration can be a contributing factor for increases in core temperature, heart rate, and decreases in sweat rate (Coyle, 2004). No significant relationship between USG and sweat rate or heart rate was found in the present study. This may have been influenced by the cool environment in which the players trained. In prolonged strenuous exercise at high temperatures, it has been shown that hypohydration can also degrade exercise performance and increase risk of heat illness. This risk is reduced in cool temperatures due to the high capacity for dry heat loss (convection and radiation) which reduces evaporative cooling requirements and sweat losses (Sawka et al., 2007; Coyle, 2004).

USG results can be influenced by differences in pre-training schedules and sport nutrition education. The majority of athletes from the present study arrived to training after a full day of school and in some cases, after school sport activities. Although hydration education was not formally assessed, only (9.1%) of our athletes reported ever having worked with, or received education from, a nutrition professional. Pre-training activity and low level of hydration education may have contributed to hypohydration in those with the highest USG, although direct assessment of this was not conducted. It is important to note that fluid consumption between time of urine collection and start of training was not measured. This time varied between 15-45 minutes before training, and it is possible that those players who presented in a hypohydrated state in the lab before training were able to consume enough fluid to improve their hydration status prior to training.
Overall, the mean USG findings and the cool environmental temperatures suggest that players did have hypohydration but were low risk for hypohydration-induced injury or illness during soccer training. The junior elite players in this study train and compete year round including through the warmer summer months, where an increased risk for hypohydration and heat illness is likely. Due to the large proportion of individual athletes presenting in a hypohydrated state, education regarding pre-training hydration is warranted in order for players to understand the role that hydration plays in optimizing performance and to develop effective, individualized hydration practices to follow throughout the year.

**Sweat Rate and Percent Body Mass Loss During Training**

There is very limited research describing the sweat rates and body mass losses of female adolescent soccer athletes, especially during training. As seen in Table 11, when comparing the present study results to other studies in adult female soccer athletes, Kilding et al. (2009) found similar sweat rates of 0.4 - 0.5L/h. Broad et al. (1996) reported higher sweat rates (0.8 ± 0.2L/h) during both training and competition in adult female soccer athletes, however environmental temperatures were much warmer (30-35°C). Participants in the current study had higher percent body mass loss than the female players in the Kilding et al., (2009) study. The range for sweat rate and percent body mass lost by players in this study was extremely large (sweat rate range = 26.7-1866.5ml/hour; percent body mass loss range = -0.28-5.21%) which suggests an individual sweat response to the training session. This large individual variability has been previously and consistently reported in the available soccer literature and across other sports (Kilding et al., 2009; Maughan et al., 2004, 2005; Shirreffs et al., 2005;
A variety of factors have been known to influence sweat rates including environmental conditions, clothing/equipment, as well as individual characteristics such as body weight, genetic predisposition, heat acclimation state and metabolic efficiency (Sawka et al., 2007). In an attempt to identify factors which may influence sweat rate, relationships were explored between sweat rate and pre-training USG, pre-training hydration status, age or body weight. No significant relationships were found to help explain sweat rate. Such a finding is consistent with that observed previously (Maughan et al., 2004, 2005, Shirreffs et al., 2005; Kilding et al., 2009). Athletes in our study performed activity in similar environmental temperatures and wearing similar clothing (team uniform of shorts and t-shirt), so factors related to genetics and metabolic efficiency may have influenced this, but were not measured.

**Fluid Intake Practices**

The present study’s participants had lower mean fluid intake during training than that reported in previous studies of adult and adolescent males as well as adult female soccer players (Kilding et al., 2009; Broad et al., 2006; Shirreffs et al., 2005; Maughan et al., 2004, 2005; Mao et al., 2001; Mjannes et al., 2006). Mean fluid intake was likely influenced by the drink break practices employed by coaches. Of seven training sessions observed during this study, six sessions only permitted a single drink break for players; no training session offered more than that. In addition, cool temperatures may also have influenced a lower intake of fluids (Maughan et al., 2005).

Table 13 describes fluid intake practices before, during and after soccer of study participants compared to the 2007 ACSM Exercise and Fluid Replacement Position Stand.
Guidelines (Sawka et al., 2007) and the 2006 US Soccer Federation (USSA) Youth Soccer Heat Stress Guidelines (U.S. Soccer Federation, 2006). Although pre-training self reported hydration appears adequate compared to the guidelines, this is not congruent with the high proportion of athletes presenting to training in a hypohydrated state. In addition participants current practices do not appear to follow suggested guidelines for hydration both during and after training.

Table 12

*Fluid Intake Practices of Study Participants Compared to Adult and Youth Hydration Guidelines*

<table>
<thead>
<tr>
<th>Timing</th>
<th>Fluid Intake Practices of Participants (mean ± SD)</th>
<th>2007 ACSM Fluid Replacement Guidelines</th>
<th>2006 USSA Youth Heat Stress Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Training*</td>
<td>• 398.3 ± 318.3ml or 5.6 ±4.4 ml/kg</td>
<td>• 5-7ml/kg for the first 4 hours</td>
<td>• Child should be well hydrated having consumed 375-500ml of fluid 30 minutes ahead of time</td>
</tr>
<tr>
<td></td>
<td>• 2 hours before</td>
<td>• ~3-5ml/kg in the 2 hours before exercise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Large range (0-19ml/kg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>During Training**</td>
<td>• Most (87.9%) did not lose &gt; 2% of their body weight</td>
<td>• Fluid intake should be customised to prevent greater than 2% body weight</td>
<td>• Drinking to be enforced periodically every 20 minutes</td>
</tr>
<tr>
<td></td>
<td>• Low intake = 195ml ± 0.24ml over 90 min.</td>
<td></td>
<td>• ~281ml fluid/20 minutes for players &gt; 41kg</td>
</tr>
<tr>
<td></td>
<td>• Participants did not fully replenish losses during training</td>
<td></td>
<td></td>
</tr>
<tr>
<td>After Training*</td>
<td>• 418.5 ± 315.4ml</td>
<td>• ~1.5L of fluid is consumed for each kg body weight lost</td>
<td>• Fluid intake start immediately and occur every 20 minutes for one hour</td>
</tr>
<tr>
<td></td>
<td>• Not enough to replace mean losses during training (688.33 ±427.44ml)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Fluid practice data from before and after training was from self reported nutrition questionnaire.**Fluid practice data from during training was collected by study investigators.
Although mean sweat rates and percent body mass losses were low, individual results and overall low fluid intake during and after training reveal some athletes were at risk for dehydration related performance decrements during training. Dehydration of greater than 2% body weight has been shown to degrade aerobic performance and cognitive/mental performance in temperate-warm-hot environments (Sawka et al., 2007). In soccer athletes, dehydration during soccer specific testing protocols has been found to be significantly related to elevated core temperature, heart rate, lactate production, ratings of perceived exertion and reductions in soccer specific skill and mental test performances (Ali et al., 2010; Edwards et al., 2007). Education of coaches regarding the availability of adequate opportunities for hydration during training session and of athletes about consuming adequate fluid should be recommended, encouraged and supported. Results of this study also support previous recommendations that hydration guidelines must be personalised for athletes and individual education is strongly indicated (Sawka et al., 2007).

**Sweat Sodium Concentration**

This is the first study to report sweat sodium concentration in adolescent female soccer athletes during training. As seen in Table 11, the mean sweat sodium concentration and total salt loss found in this study, using the low back regional site for sweat patches, are similar to what has been previously reported for female soccer athletes by Kilding et al., (2009) (45.1 ± 11.4mmols/L, 1.8-1.9g) but variable compared values found in adult male soccer athletes (Table 11) as well in adolescent male ice hockey athletes using forehead patches (54mmol/L, ~2.3g) (Palmer & Spriet, 2009). It is important to note that research by Maughan et al., (2004, 2005), Shirreffs et al., (2005,
2006) and Kilding et al., (2009), determined mean whole body sweat sodium concentration from the 4 site regression equation by Patterson et al., (2000), thus making a true comparison to the current results difficult. In the present study, the Patterson et al., (2000) equation could only be applied to 6 (9.1%) athletes, which resulted in a mean whole body sodium concentration of 57.7± 9.3mmols/L (2.4g salt loss). This appears higher than previously reported values in female adult players however, due to the small sample size, a valid comparison is not possible.

The inability to reliably collect sweat samples from commonly used regional sites was a consistent trend in this study. This finding could prove to be an important methodological consideration for future sweat sodium testing in this population using the closed patch method. The Patterson et al., (2000) method and regression equation were developed based on comparing regional sodium concentration to a whole body wash down method in adult male endurance athletes. Further research validating the Patterson et al. (2000) method as well as investigating regional site variation in sweat sodium concentration across different temperatures and exercise intensities is needed in adolescent athletes, specifically females.

Sodium losses in sweat are mediated by genetic, environmental and dietary factors and are thus highly individualised (Eichner, 2008). Previously, a high sodium diet significantly increased sweat sodium excretion compared to moderate and low sodium diets in a heat acclimatized study in adult men (Allsop, Sutherland, Wood & Wootton, 1988). No significant correlations between sweat sodium concentration or salt losses (across all regional sites tested) and sodium intake were observed in the present study, despite the high dietary intake of sodium by players (p=0.103, p=0.314, respectively).
Restoration of electrolytes, especially sodium, has been shown to be a prerequisite for restoration of fluid balance after exercise (Shirreffs, Armstrong, & Cheuvront, 2004; Takamata, Mack, Gillen & Nadel, 1994; Shirreffs & Maughan, 1998). The literature suggests that athletes who are prone to large sodium losses may be at greater risk for sodium deficits, heat cramping, plasma volume contraction as well as a hypovolemic hyponatremia (Eichner, 2008; Bergeron, 2003; Stofan, Zachwiega, & Horswill, 2005). Self reported problems with muscle cramping by study participants were moderate 13 (39.4%), however the etiology of muscle cramps can be from a variety of factors (Eichner, 2008). The mean sweat sodium losses (1.9g) experienced by participants in this study were likely replaced as dietary sodium intake was high (exceeding the Upper Tolerable intake by 133.7% ± 40.7%), suggesting that participants are likely at low risk for sodium deficits.
### Table 13

Comparison of Hydration, Fluid Balance and Sweat Sodium Loss from Present and Previous Data Involving Soccer Athletes

<table>
<thead>
<tr>
<th>Reference</th>
<th>Amb. Temp.</th>
<th>Rel. Humidity (%)</th>
<th>n</th>
<th>Age (years)</th>
<th>Pre-training Hydration Status</th>
<th>Sweat Loss Total (L)</th>
<th>Sweat Rate Total (L/h)</th>
<th>Fluid Intake (L)</th>
<th>Dehydration (%)</th>
<th>Mean Na+ loss (mmol/L)</th>
<th>Corr. Na+ loss (mmol/L)</th>
<th>Sweat Sodium Loss (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilding et al., 2009</td>
<td>T1 14</td>
<td>T1 71</td>
<td>13F</td>
<td>23±5</td>
<td>1.014±0.005*</td>
<td>0.7±0.3</td>
<td>0.5±0.2</td>
<td>0.5±0.3</td>
<td>0.6±0.5</td>
<td>43.9±13.8</td>
<td>28</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>T2 6</td>
<td>T2 74</td>
<td>30F</td>
<td>16-28</td>
<td>1.011±0.055*</td>
<td>0.7±0.2</td>
<td>0.4±0.1</td>
<td>0.4±0.1</td>
<td>0.5±0.4</td>
<td>46.2±7.9</td>
<td>30</td>
<td>1.9</td>
</tr>
<tr>
<td>Broad et al., 1996 #</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*Based on urine specific gravity (USG) measured by USG. A USG &gt;1.020 indicates a state of mild hyphdration.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shirreffs et al., 2005</td>
<td>32</td>
<td>20</td>
<td>26M</td>
<td>26±4</td>
<td>-</td>
<td>2.2±0.4</td>
<td>1.5</td>
<td>1±0.3</td>
<td>1.6±0.6</td>
<td>30</td>
<td>20</td>
<td>3.8</td>
</tr>
<tr>
<td>Maughan et al., 2004</td>
<td>27</td>
<td>55</td>
<td>24M</td>
<td>27±4</td>
<td>666±311 mosmol.kg**</td>
<td>2</td>
<td>1.4</td>
<td>1±0.3</td>
<td>1.4±0.4</td>
<td>49</td>
<td>32</td>
<td>5.8</td>
</tr>
<tr>
<td>Maughan et al., 2005</td>
<td>5</td>
<td>81</td>
<td>17M</td>
<td>24±4</td>
<td>872±1177 mosmol.kg**</td>
<td>1.7±0.5</td>
<td>1.1</td>
<td>0.4±0.2</td>
<td>1.6±0.6</td>
<td>42±13</td>
<td>27</td>
<td>4.3</td>
</tr>
<tr>
<td>Mao et al., 2001</td>
<td>34.5 indoor</td>
<td>40 indoor</td>
<td>13M</td>
<td>16-18</td>
<td>-</td>
<td>1.5±0.6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>55±27</td>
<td>-</td>
<td>5.9</td>
</tr>
<tr>
<td>Unpublished data cited in</td>
<td>-</td>
<td>-</td>
<td>39F</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Shirreffs et al., 2006</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td>*Based on urine specific gravity (USG) measured by USG. A USG &gt;1.020 indicates a state of mild hyphdration.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mjannes et al., 2006 (abstract)</td>
<td>-</td>
<td>-</td>
<td>19F</td>
<td>11-16</td>
<td>-</td>
<td>0.5±0.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Present Study</td>
<td>6-14</td>
<td>59-79</td>
<td>34F</td>
<td>15±0.7</td>
<td>1.018±0.009*</td>
<td>0.7±0.4</td>
<td>0.5±0.3</td>
<td>0.2±0.2</td>
<td>0.8±0.7</td>
<td>47.6±11.9</td>
<td>low back</td>
<td>31</td>
</tr>
</tbody>
</table>

*Based on urine specific gravity (USG) measured by USG. A USG >1.020 indicates a state of mild hyphdration.

** Based on urine osmolality. A urine osmolality above 900 mosmol/kg indicates a state of mild hypohydration.
**Energy Balance**

The results from this study reveal mean daily energy intake of the players to be 2079 ± 460 kcal/day with a large range of caloric intake (1292-3231 kcal/day). This is consistent with findings in adult female soccer athletes by Mullinix et al. (2003) and Martin et al. (2006) who reported mean intakes of 2015 ± 19 kcal/day and 1904 ± 366 kcal/day respectively. Clarke et al. (2003) also found similar energy intakes in the pre season (mean energy intake of 2290 ± 310 kcal/day) with lower post season intakes (1865 ± 530 kcal/day) in adult NCAA female soccer athletes.

There was a statistically significant difference between energy intake and expenditure (p ≤ 0.05), which resulted in a mean energy deficit of 462 ± 549 kcal suggesting energy balance was not achieved by athletes. This result however, should be interpreted with caution as it is likely influenced by errors in self-reporting. Dietary intake measurement is influenced by errors in precision, recall and compliance (Bingham, 1985). Under-reporting of dietary intake has been previously identified in adolescent athletes (Caccialanza, Cameletti & Cavallaro, 2007). Mean intake of vitamin E was below recommendations for all athletes, which could suggest under-reporting of fat used in cooking or from condiments such as spreads and salad dressings, influencing total energy intake values. Estimates of energy expenditure were predicted using equations versus direct methods thus an overestimation of energy expenditure could have also occurred and thus influenced energy balance to a greater extent (Burke & Deakin, 2007; Caccialanza, Cameletti & Cavallaro, 2007). In addition, when considering BMI and body composition results, values are not suggestive of a high incidence of overly lean or underweight athletes.
Although education was given to each athlete regarding food recording techniques and estimations of household measures, future studies in this population should also include parents in this education to help encourage cooperation. Using weighted food records, a longer period of time for food recording and more quantitative measures of physical activity (questionnaires, pedometers or accelerometry) could also be implemented to increase accuracy of energy intake and expenditure data, however these methods involve greater levels of athlete compliance, education and involvement.

**Macronutrient Intake**

Athletes in this study consumed adequate mean intakes of carbohydrate, protein and fat, with the exception of fibre, when compared to Dietary Reference Intake recommendations as well as sport nutrition recommendations (Otten et al., 2006; Rosenbloom et al., 2006; Tipton & Wolfe, 2004; Burke et al., 2004). Mean fibre intake below the Adequate Intake (AI) has been previously reported in both the general population and in elite junior athletes. The Canadian Community Health Survey (Cycle 2.2, 2004), found mean fibre intake of females (14-18 years old) to be 14.0g/day (Health Canada, 2009), and low intakes have been reported in female adolescent athletes across a range of sports including soccer (DeSousa et al., 2008) and artistic gymnastics (Jonnalagga, et al., 1998). An underestimation of fibre intake could be influenced by database errors when conducting nutrition analysis. The Canadian Nutrient File only reports naturally occurring fibre in foods and not functional fibres (added fibre to foods) therefore resulting in the risk of underestimating intake (Health Canada, 2009). Since this cannot be quantified, education around the importance of fibre in athletes’ diets should be addressed and is an important area for sports nutrition education.
Carbohydrate is the primary fuel used during soccer and a daily intake of 5-7g/kg has been suggested in adult soccer athletes for recovery from training of low intensity and moderate duration (Rosenbloom et al., 2006; Burke et al., 2004). In the present study, mean carbohydrate intake was at the low end of this recommended range (5.0 ± 1.6 g/kg) and when examining individual data, 51.5% of players consumed less than these recommendations. These results concur with other published studies which have reported mean intake of less than 5g/kg in adult female players (Martin et al., 2006; Mullinix et al., 2002; Clark et al., 2003), adolescent male soccer athletes (Caccialanza et al., 2007; Ruiz et al., 2005; Iglesias-Gutierrez et al., 2005) as well as adolescent female athletes from other sports such as swimming, cycling, netball, softball, track and field, volleyball and water polo (Farajian et al., 2004; Hassapidou et al., 2002; Heaney et al., 2010).

Athletes in our present study were training at high training intensities (68 ± 5% heart rate max) and the repeated, high intensity bouts of activity needed for soccer performance indicate a heavy reliance on carbohydrate as an energy source (Rosenbloom et al., 2006; Rico-Sanz, Zehnder, Buchli, Dambach & Boutellier, 1999; Zehnder, Rico-Sanz, Kuhne, & Boutellier, 2000). Suboptimal carbohydrate intake therefore, could result in insufficient glycogen resynthesis after training, leading to compromised muscle glycogen levels in athletes (Rosenbloom et al., 2006; Rico-Sanz, Zehnder et al., 1999; Zehnder, Rico-Sanz et al., 2000). Using nuclear magnetic resonance, Rico-Sanz et al., (1999) examined the individual glycogen degradation response during a soccer specific fatigue test in 17 elite male late adolescent soccer athletes (17.4 ± 0.8 years old). Results showed a net muscle glycogen degradation of 36% of the resting value at exhaustion. Zehnder et al., (2000) used nuclear magnetic resonance as well as the same glycogen
depleting soccer fatigue test as Rico-Sanz et al., (1999) to examine the effects of habitual post-test 24 hour dietary intake on glycogen replacement in 12 male elite soccer athletes (17.5 ± 0.8 years old). Players consumed a mean daily intake of 4.8 ± 1.8g/kg, which was not sufficient (~90%) to completely replenish muscle glycogen stores to pre-test levels.

Research investigating the effect of soccer activity on glycogen degradation in adolescent female soccer athletes is needed as it could reveal unique gender differences and inform carbohydrate intake recommendations (Rosenbloom et al., 2006). Based on the work by Rico-Sanz et al., (1999) and Zender et al., (2000), results from the participants in the present study reveal that almost half of athletes were not be replenishing losses experienced in intense training sessions and games. This may ultimately impact training and match performance and risk of musculoskeletal injury by earlier onset of glycogen depletion leading to muscular fatigue. This is especially important for adolescent players since youth soccer tournaments frequently have several matches scheduled for a single team within a short time period (Rosenbloom et al., 2006; Rico-Sanz et al., 1999; Zender et al., 2000). Although the low reported carbohydrate intake results from the present study may be influenced by potential underreporting, it appears that optimizing carbohydrate intake is an important consideration for athletes. Further education as well as increased daily intake of carbohydrate, including appropriate fibre content, that also considers individual energy balance and body composition is likely warranted.

Protein is a critical macronutrient needed in adolescent athletes to help accommodate rapid growth and development, stimulate lean tissue growth and remodeling as well as a potential energy source for performance (Petrie et al., 2004;
Boisseau, Vermorel, Rance, Duché, & Patureau-Mirand, 2007; Boisseau, Le Creff, Loyens, & Poortmans, 2002). Dietary Reference Intake (DRI) values for protein suggest that relative daily intakes for females between 14-18 years of age to be between 0.76 (EAR) -0.85 (RDA)g/kg (Otten et al., 2006). Mean intakes from players in the present study were within this daily reference range (1.38 ± 0.3g/kg), however this recommendation is based on average adolescents rather than an athletic population involved in regular intensive exercise.

Protein intake recommendations between the ranges of 1.2-1.7 g/kg/day have been suggested as guidelines for soccer athletes and those involved in intermittent (“stop and go”) sport in order to support muscle protein synthesis and repair (Rosenbloom et al., 2006; Tipton et al., 2004; Boisseau et al., 2007; Boisseau et al., 2002; Lemon, 1994). Using a short term, repeated nitrogen balance study by Boisseau et al., 2007, 11 male adolescent elite French soccer players (13.8 ± 0.1 year) living at a sports training centre were fed diets with varying levels of protein intake (1.0, 1.2, 1.4 g/kg). Researchers found at energy equilibrium, a daily protein intake of 1.04g/kg was needed to balance nitrogen losses, which would correspond to an EAR requirement of 1.20g/kg and a RDA of 1.4g/kg (Boisseau et al., 2007). In an earlier study, Boisseau et al., (2002) used 7 day food records to assess dietary protein intake relative to urinary nitrogen balance in 8 non-active and 11 adolescent male soccer players (15 ± 1.0 years old) and found positive nitrogen balance at 1.57g/kg. These studies support the hypothesis that soccer athletes likely need greater relative intakes of protein when compared to general non-active, population guidelines.
Although mean intake suggests the athletes from the current study were meeting their protein needs, 27.3% of individuals were consuming less than 1.2g/kg. Martin et al., (2006) and Mullinix et al., (2002) which found adult female players consumed mean intakes of greater than 1.2g/kg protein, however Clarke et al., (2002) reported low post season mean protein intakes (0.96±0.03g/kg) in NCAA soccer players. Research investigating the effect of various levels of protein intake on nitrogen balance in adolescent female soccer athletes is needed and could reveal unique gender differences which could inform the development of age-appropriate protein intake recommendations (Rosenbloom et al., 2006). Players in the current study should be encouraged to continue current practice. Individual consultation to those under consuming protein education is warranted.

Dietary fat provides an essential energy source for soccer performance as well as the increased growth needs of adolescents (Petrie et al., 2004). In addition, dietary fat also helps with the absorption of critical fat soluble vitamins and carotenoids (Petrie et al., 2004). Mean fat intake for players in this study was 29.9±5.8% with 10.1±2.6% saturated fat contributing to total intake. This intake is within recommended ranges when compared to the DRI’s Acceptable Macronutrient Distribution Range of 25-25% of total energy coming from fat (Otten et al., 2006) and also in accordance with <30% of total energy recommended by Ruiz et al., (2005) for soccer athletes, and Petrie et al., (2004) for active child and adolescent athletes. This range of intake is similar to that described in adult female soccer and adolescent male soccer athletes (Clarke et al., 2003, Mullinix et al., 2003; Martin et al., 2006; De Sousa et al., 2008; Caccialanza et al., 2007; Iglesias-Gutierrez et al. 2005; Rico-Sanz et al., 1998; Ruiz et al., 2005). A small proportion of
athletes in the present study (21.2%) consumed less than this appropriate range, which could have influenced by reporting errors, however individual follow up would be recommended. The majority of athletes in the current study should be encouraged to continue current practice.

**Micronutrient Intake**

For most micronutrients, mean intake of participants exceeded DRI (EAR or RDA/AI) recommendations, however marginal intakes of pantothenic acid, folate, vitamin D, vitamin E and calcium were found. Although most athlete’s diets were adequate, a number of individuals also failed to meet the EAR and AI intakes for a variety of nutrients. These findings concur with other studies that have reported the micronutrient intake of female adult soccer athletes. Martin et al., (2006) reported mean intake of vitamin A and iron below recommended daily intake values in adult female players from England. A pilot study by Mullinix et al., (2002) revealed mean intakes below DRI values for vitamin E, D, folate, calcium, magnesium, phosphorous and zinc in the U21 American female soccer team. Clark et al., (2003) reported mean intakes of vitamin E, D, folate, biotin and B5 were less than 75% of the DRI pre and post season adult NCAA players.

Vitamin E is a powerful antioxidant, which plays a critical role in cell membrane protection from oxidative damage (Rodrigues et al., 2009). Evidence is still lacking, however sport nutrition research suggests that vitamin E intake may be increased in endurance athletes and could help attenuate post exercise cellular damage as well as enhance recovery (Rodrigues et al., 2009). The low vitamin E intake of athletes in this study could be influenced by a low dietary intake of fat and energy (Rodrigues et al.,
2009; Jonnalagga et al., 1998). However, as other authors have suggested, low vitamin E intake could also be a result of underreporting of fat used in cooking or other fat-containing condiments (Jonnalagga et al., 1998). Additional research is needed to validate this result using more robust food recording protocol and increased vitamin E intake recommendations should be approached with caution for current study participants.

Pantothenic acid and folate are critical B-vitamins involved in energy metabolism and red blood cell production, protein synthesis, as well as tissue repair and maintenance (Rodrigues, et al., 2009). Suboptimal dietary intake of these B-vitamins could be attributed to low intakes of nutrient dense and fortified foods such as whole grains as well as fruits and vegetables, which are often replaced by more “processed”, less nutrient dense choices (Clark et al., 2003). A large proportion of individual athletes in the present did not consume adequate intake of fibre or carbohydrate which would support the suboptimal folate and B5 intake. Deficiencies in folate and B12 have been linked to reductions in endurance performance and anemia (Rodrigues et al., 2009). Given the important role that these B-vitamins play in exercise metabolism, education emphasizing nutrient dense food choices from a variety of sources would be recommended.

Adequate intake of calcium and vitamin D is essential for optimizing bone mineral density, and is critically important in adolescents as they are forming their peak bone mass during this stage of the lifecycle (Petrie et al., 2004; Rosenbloom et al., 2006). Calcium is involved in the development, maintenance and repair of bone, as well as regulation of muscle contraction, blood clotting and nerve conduction (Rodrigues et al., 2009; Burke & Deakin, 2007). Vitamin D is also involved in the promotion of bone health and is required to facilitate calcium absorption and regulate serum calcium and
phosphorus levels (Rodriques et al., 2009). Inadequate intake of both calcium and vitamin D could place athletes at risk for lower bone mineral density and stress fractures (Rodriques et al., 2009) as well as premature fatigue development during training and/or competition. Low energy intake as well as low consumption of dairy products and other calcium rich foods is likely contributing to the suboptimal intake of athletes in the present study (Rodriques et al., 2009). Dietary education regarding increased intake of calcium and vitamin D rich foods would be highly recommended for participants.

**Nutrition Practices**

Results from the present study provide important information regarding nutrition practices of female junior elite soccer athletes. Since all athletes lived at home with at least one parent, it is not surprising that the majority of athletes did not shop or prepare their own meals. Although not formally assessed within this research, this would suggest a low skill level for grocery shopping and meal preparation, and as a result, a low level of awareness of food quality and nutrient content of foods being consumed. A very low proportion (9.1%) of athletes had worked or received education from a Registered Dietitian or nutrition professional. Given the large number of athletes in the present study with nutrition and hydration inadequacies as well as the important role nutrition and hydration play in achieving optimal athletic performance, formal education in nutrition would be recommended.

Dietary supplements were used by a small proportion (12.1%) of athletes in this study. This incidence of use is much lower than what has been previously reported in the literature. In a recent study by Braun, Koehler, Geyer, Kleinert, Mester, & Schänzer (2009), 164 elite young athletes (16.6 ± 3.0 years of age) from a variety of sports within
the German Olympic Sports Confederation were surveyed regarding supplement use and 80% of all athletes reported using at least 1 supplement. In a cross sectional study of Canadian high-performance adult athletes (314 male, 268 female; 19.96 ± 3.91 years), representing 27 sports, 88.4% of participants reported taking ≥ 1 dietary supplement (mean of 3.08 ± 1.87 supplement per user) (Erdman, Fung, Doyle-Baker, Verhoef, & Reimer, 2007). Further research is needed to validate and explain the lower mean use of supplements in this specific population of athletes.

**Hematological Assessment**

Hematological analysis of prealbumin, iron markers, vitamin D status revealed that the majority of athletes in the present study were within normal clinical ranges. Mean serum prealbumin levels observed in the current study were well in normal ranges, with no individual athletes below reference ranges. Prealbumin is serum marker used to assess protein-energy status with low levels commonly used in a clinical setting as an indicator of malnutrition (Shenkin, 2006). Low prealbumin levels have been found in athletes who engage in energy restriction for weight class sports such as wrestling (Loukes, 2004).

Iron is a mineral that is involved in many essential functions including oxygen storage and transport, energy production and metabolism as well as immune and central nervous system function (Burke & Deakin, 2007). It has been well reported in the literature that female adolescent athletes are at high risk for iron depletion and deficiency due to the combination of high iron turnover required for growth, loss from menses, suboptimal dietary intake of energy and iron and the requirements from intense physical training (Constantini, Eliakim, Zigel, Yaaron, & Falk, 2000; Pate, Miller, Davis, Slentz & Klingshirm, 1993; Dubnov & Constantini, 2004; Fallon, 2004; Burke & Deakin, 2007).
Mean hematological results for iron status indicators revealed that athletes in the present study were within normal reference ranges, with a small proportion of athletes with iron depletion (n=2) and deficiency (n=1).

Although somewhat controversial, cut-off values for serum ferritin of <20ug/L and <35ug/L have been suggested as a marker for iron depletion in athletes and thus a basis on which to recommend iron supplementation (Nielsen & Nachigall, 1998; Fallon, 2004; Hinton, Giordano, Brownlie & Haas, 2000; Hinton et al., 2000; Freidmann et al., 2000). When applying these cut off values to current results, the majority of athletes (89.3%) had serum ferritin values < 35ug/L, and almost half (46.4%) had values <20ug/L. These data suggest a high level of iron depletion within this current population, which concurs with previously reported literature in female athletes (Constantini, et al., 2000; Pate et al., 1993; Dubnov & Constantini, 2004; Fallon, 2004; Burke and Deakin, 2007).

Although a conclusion is tempting to draw, diagnosis of iron depletion in adolescent females using the single measure of serum ferritin alone may be confounded by increased plasma volume with growth spurts, training responses such as inflammation as well as dietary intake of iron, acute and chronic disease (Burke & Deakin, 2007; Woolf, Thomas, Hahn, Vaughan, Carlson & Hinton, 2009). Although participants were asked to present for blood tests in a hydrated state and refrain from intense physical activity within 24 hours prior, compliance to this was not controlled.

Recently, measurement of serum transferrin receptor as an indirect marker of functional iron storage in athletes has been implemented and is less susceptible to change with inflammation and infection (Woolf et al., 2009; Burke & Deakin, 2007). This
transferrin receptor value can be used with serum ferritin to determine the transferrin receptor index, which represents the ratio of functional iron to storage iron (Woolf et al., 2009; Burke & Deakin, 2007). Further, more robust iron studies including transferrin receptor information related to adolescent females is recommended for the athletic youth soccer population.

It is well known that in northern latitudes, serum levels of vitamin D changes with the season and winter time vitamin D insufficiency has been demonstrated in young Canadian women irrespective of their dietary intake (Vieth, Cole, Hawker, Trang & Rubim, 2001). Given the critical role that vitamin D plays in bone health, immunity and exercise related inflammation, it has recently been recommended that athletes are screened for vitamin D status (Willis, Peterson, Larson-Meyer, 2008).

As indicated in a comprehensive review by Willis, Peterson & Larson-Meyer, (2008), circulating concentrations serum 25-hydroxyvitamin D of 20–29 nmol/L will prevent rickets, but concentrations of at least 75–80 nmol/L are needed to support optimal health and disease prevention. Using 75nmol/L as a cut off, half of the participants (50.0%) in the current study did not meet these recommendations. These lower than recommended 25-hydroxyvitamin D levels could to the observed low mean intake of vitamin D (81.6% ± 47.4% were below DRI) combined with low levels of sun exposure (data was taken during the spring months in Canada). Although soccer is an outdoor sport, many youth athletes including those in the present study, train during evenings. The suggested ranges apply to adult athletes, and thus it is difficult to extrapolate them to this adolescent population. More longitudinal data are needed to assess the impact of seasonal variation in this group. Due to low dietary intake,
education about increasing vitamin D from dietary sources is recommended.

**Limitations**

There are several notable limitations of this research. These include the restricted generalizability of the data, lack of control over several variables, potential for recording errors and methods used in the interpretation of results. Due to the cross sectional nature of this study, data were collected over a small timeframe and thus may not accurately represent the true nutrition and hydration intake and practices of the junior elite female soccer athletes involved. A longitudinal assessment of hydration in different environmental temperatures as well as during match play would provide a better indicator of practices and losses. In addition, repeated measurement of anthropometrics, nutrition intake and hematological parameters would better inform nutrition status and how phase of training and season effect these variables.

The study aimed to assess hydration status and practices as they naturally occur during training. Many variables such as training intensity, menstrual phase, breaks for fluid intake and environmental temperatures although recorded, were not controlled for. Controlling for these variables would be advised for additional studies to investigate the sweating response and sodium losses in this population in order better inform the understanding of female adolescent athlete sweat physiology.

When having bloodwork taken, participants were given instruction to arrive to the lab in a rested and hydrated state, preferably fasted. Since blood work was taken at an external lab at the athlete’s discretion, this could not be controlled for and thus hematological results could have been impacted these such factors.

Although normal hydration and nutrition practices players were encouraged by
study investigators, there is a possibility that usual intake/practices of coaches and players may have been influenced by the study. As previously mentioned, there are many errors associated with food reporting which include underreporting, recall bias, change of habitual intake as well as non-compliance (Bingham et al, 1985). In addition to this, error may have occurred with entry of food items into dietary analysis program. Foods that were not available within the Canadian Nutrient File database, were either substituted with a similar food item or manually added into the system using information provided from company websites.

Lastly, the interpretation of this study’s results is limited by the restricted amount of research available in this population and the lack of population specific guidelines for junior elite female athletes. Until a larger body of evidence is available, comparisons to adult, adolescent male and non-active healthy adolescents must be used.

Conclusion

The current study provides valuable information describing the nutrition and hydration status and practices of junior elite female soccer athletes. Junior elite female soccer players experienced similar sweat rates and electrolyte losses as female adult players. The hypohydrated state, low consumption of fluids during training, typically devoid of sodium, and the limited access to fluids during training provide evidence of less than optimal hydration practices. All players in this study had a body composition within healthy ranges, however the majority consumed suboptimal mean intakes of energy, carbohydrate, fibre and the critical micronutrients calcium, vitamin D, E, folate and pantothenic acid. Although the hematological parameters assessed were within normal clinical ranges, recommendations for athletic populations suggest players may be
at risk for iron depletion and suboptimal 25-hydroxyvitamin D stores. Lastly, due to the limited exposure to nutrition education reported in their elite careers so far, an opportunity for formal education in sport nutrition education exists.

Additional research in female adolescent soccer athletes is warranted to support these preliminary findings and develop hydration and nutrition practice guidelines specific to this population. According to the Long Term Athlete Development model (LTAD), adolescent females are within the critical stages of “train to train” (11-15 years) and “train to compete” (15-21+years) (Canadian Sport for Life, 2010). The LTAD model defines these stages as times where athletes consolidate their basic sport specific skills and physical development and then move on to become specialists within their sport and training at a high level and volume (Canadian Sport for Life, 2010). Optimal nutrition and hydration are the essential foundations needed to fuel both the physical and sport development of these young athletes. With the growing number of female soccer athletes in Canada, guidelines specific to the unique needs of this population are essential to ensure not only the health and well-being of players, but for the development of the next generation of high performance, Canadian athletes.
References


temperature responses in adolescent tennis players: Sports beverage versus


Boisseau, N., Le Creff, C., Loyens, M., & Poortmans, J. (2002). Protein intake and


Appendix A
Review of Literature

Introduction

The following review of literature includes a summary of the physiological, nutrition and hydration considerations in adolescence with a focus on the female athlete. The metabolic demands of soccer training are described and available literature in nutrition and hydration for soccer and related sports is comprehensively reviewed.

Physiological, Hydration and Nutrition Considerations of Adolescent Athletes

Adolescence is a dynamic time in the life cycle that is physically characterized by the rapid growth and maturation of many physiological characteristics. During puberty, the body attains optimal skeletal and muscular growth, cognitive function, neuromuscular coordination as well as cardiovascular fitness (Burke & Deakin, 2007). Puberty is accompanied by a rapid increase in sex steroid and growth factors, which accelerates the development of these characteristics and can help to increase trainability for athletic potential (Rowland, 2007).

Due to the differences in physiology of thermoregulation, adolescent athletes may be at high risk for dehydration, heat stress and heat injury, especially if the sport is played outdoors, where athletes are also susceptible to environmental stressors (Burke & Deakin, 2007). The sweat response for cooling the body is less efficient in children and approaches adult rates in early puberty (Falk, Bar-Or, & MacDougal, 1992). There is a greater dependency on convection and radiation compared to evaporation thus children with high levels of body fat and heavy builds may be more susceptible to heat stress (Bar-Or, 1995). Young athletes have been shown to dehydrate more quickly when left to drink on their own, which may be caused by a reduced physiological drive to drink and a faster rise in core temperature than adults (Bar-Or & Wilk, 1996). These underdeveloped thermoregulatory mechanisms can lead to increased risk for dehydration, which has obvious impacts on health, physical and mental performance.
When compared to males, adolescent females athletes are at greater risk for suboptimal energy and carbohydrate intake (Loukes, 2004; Burke, Cox, Cummings, & Desbrow, 2001; Rosenbloom et al., 2006). Intense physical training, especially when combined with poor nutrition, can have negative effects on skeletal muscle growth and maturation. Negative energy balance can result in chronic under nutrition, which compromises skeletal growth and delays maturation (Burke & Deakin, 2007). In a study of 21 gymnasts, energy intake was an independent predictor of growth velocity and correlated with the delay in skeletal maturation (Bass et al., 2000). In addition to compromising the attainment of final height, poor nutrition can delay menarche in females, which is a risk factor for menstrual dysfunction (secondary amenorrhea). (Burke & Deakin, 2007; Mansfield & Emans, 1993; Loukes, 2006), Menstrual dysfunction can result a variety of issues including irreversible low peak bone density (Micklesfield, Reyneke, Fataar, & Myburgh, 1998; Loukes, 2006).

Iron is a mineral that is involved in many essential functions including oxygen storage and transport, energy production and metabolism as well as immune and central nervous system function. Greater needs for iron occur during growth phases (children, adolescents, pregnancy), during hard physical training and when living, sleeping and/or training at altitude (Burke & Deakin, 2007). Several factors influence iron status and include: dietary intake (iron and energy), iron absorption/bioavailability, iron loss (blood loss from menstruation, injury or disease, sweat, gastrointestinal trauma, and foot strike hematuria), long term use of anti-inflammatory medication, exercise type and volume (Burke & Deakin, 2007).

It has been previously demonstrated that athletic populations, especially female and adolescent athletes have the highest prevalence of iron depletion (Burke et al., 2000; Constantini et al., 2000; Pate et al., 1993; Dubnov & Constantini, 2004; Fallon, 2004). Prevalence of iron deficiency anemia (IDA) in adult athletes is usually low (less than 3%) however NHANES II survey data demonstrated a much higher rate of IDA in healthy adolescents (9-10% of girls and 1% of boys) (Looker, Dallman, Carroll, Gunter, & Johnson, 1997). Iron depletion, if not detected and treated early enough, can develop into IDA. IDA disturbs brain and muscle metabolism, impairs aerobic processes, endurance performance, and work capacity, as well as immune response and temperature control.
Although somewhat controversial, cut-off values for serum ferritin of <20 ug/L and <35 ug/L have been suggested as a marker for iron depletion in athletes and thus a basis on which to recommend iron supplementation (Nielsen & Nachigall, 1998; Fallon, 2004; Hinton, Giordano, Brownlie & Haas, 2000; Hinton et al., 2000; Freidmann et al., 2000).

**Nutrition and Hydration Considerations for Soccer Performance**

Soccer has been characterised as intermittent, high intensity exercise, with high metabolic demands as a result of acceleration and stopping, turning, jumping and tackling actions involved (Clark et al., 2001; Rosenbloom et al., 2006). During a match, adult male players cover an average distance of 11km (females cover less distance), maintain a relative intensity of ~70% of maximal oxygen (male and female players), with reported energy expenditures of 1100kcal (based on 60kg player) – 4500 kcals. (Rosenbloom et al., 2006; Clark et al., 2005). The repeated, high intensity bouts of activity needed for soccer performance also indicate a heavy reliance on carbohydrate as an energy source (Rosenbloom et al., 2006; Rico-Sanz, Zehnder, Buchli, Dambach & Boutellier, 1999; Zehnder, Rico-Sanz, Kuhne, & Boutellier, 2000).

Using nuclear magnetic resonance, Rico-Sanz et al., (1999) examined the individual glycogen degradation response during a soccer specific fatigue test in 17 elite male late adolescent soccer athletes (17.4 ± 0.8 years old). Researchers showed a net muscle glycogen degradation of 36% of the resting value at exhaustion. Based on the physiological demands of soccer performance, athletes must ensure adequate energy and carbohydrate intake to support performance. Suboptimal energy intake rich in carbohydrate could result in insufficient glycogen resynthesis and compromised muscle glycogen levels and thus performance in athletes (Rosenbloom et al., 2006; Rico-Sanz, Zehnder, Buchli, Dambach & Boutellier, 1999; Zehnder, Rico-Sanz, Kuhne, & Boutellier, 2000).

The high metabolic demands of soccer performance coupled the environmental factors involved with play indicate players are also at risk for dehydration (Rosenbloom et al., 2006). Dehydration of >2% body weight has been shown to degrade aerobic performance and cognitive/mental performance in temperate, warm and hot environments across a variety of sports (Sawka et al., 2007; Coyle et al., 2004).
Gant (2010), investigated the effect of water consumption (3ml/kg) or no fluid on hydration measures during a 90 minute performance of the Loughborough Intermittent Shuttle Test (LIST) in 10 National team female soccer athletes (25.5 ± 5.2 years). Results revealed that when compared to the water group, the no fluid group had greater body mass losses, higher core temperature, heart rate, lactate and ratings of perceived exertion (Ali et al., 2010). In a similar study in moderately active male soccer athletes (24.4 ± 3 years), Edwards et al., (2007) investigated the effect of three hydration treatments (fluid intake at 2ml/kg, no fluid intake and mouth rinse) on hydration measures in three experimental procedures (45 minute pre match cycle ergometry, 45 minute soccer match, and post match sport specific and mental concentration tests). The no fluid group had higher core temperatures during the soccer match, and poorer post match tests and ratings of perceived exertion (Edwards et al., 2007).

Hydration research to date in soccer has shown that athletes are not replacing losses during sport, have higher sweat and electrolyte losses than non-athletes, higher sweat rates with increasing age as well as large inter-individual variation of sweating responses and intake practices (Mjaanes, Horswill, & Stover, 2006; Mao, Chen, & Ko, 2001; Broad, Burke, Cox, Heeley, & Riley, 1996; Rico-Sanz, Frontera, Rivera, Riverabrown, Mole, & Meredith, 1996; Shirreffs, Aragon-Vargas, Chamorro, Maughan, Serratosa, & Zachweija, 2005; Maughan, Shirreffs, Merson, & Horswill, 2005; Kilding, Tunstall, Wraith, Good, Gammon, & Smith, 2009; Maughan, Merson, Broad, & Shirreffs, 2004). Due to the previously discussed detriments to soccer performance and health, adequate hydration is an essential consideration for soccer athletes.

Hydration Research in Soccer

There is very limited hydration research describing the fluid practices and status of male and female adolescent soccer athletes. Research to date has shown that young athletes are not consuming adequate intakes of fluid, not replacing losses during sport, have higher sweat and electrolyte losses than non-athletes as well as higher sweat rates with increasing age (Broad et al. 1996; Mao et al. 2001; Mjaanes et al. 2006; Rico-Sanz et al. 1996). Hydration research in female adult players is quite limited and to date only one article is available describing sweat and sodium losses in a cool environment (Kilding et al., 2009). Research in male adult players, is more available and has examined
fluid balance and sweat sodium losses in both warm and cool temperatures (Shirreffs et al., 2005; Maughan et al., 2004; 2005). Studies of adults also support the notion that players do not replace losses during training as well as a large inter-individual variation in sweat responses and fluid intake practices (Kilding et al., 2009; Shirreffs et al., 2005; Maughan et al., 2004; 2005).

In one of the only well described studies hydration studies to include females, Broad et al. (1996) investigated the body weight changes and voluntary fluid intakes during training and competition sessions of National team sports (netball, handball, soccer and basketball) training at the Australian Institute of sport. 32 male (16-18 years) and 17 female (16-28 years) soccer athletes were assessed between 1993-1995. Sweat rate (pre and post weighing method), fluid intake (fluid measured by food scale) and percent dehydration (intake versus loss) were measured in both summer and winter months (males only) and in weight training (males only), field training and competition. During weight training males had 0.3-0.4% (SD=0.2-0.4%) dehydration, 0.8-1.2% (SD=0.5-0.7%) dehydration in field training and 1.4% (SD=0.7-0.9%) during competition. Females had 0.9% (SD=0.5%) dehydration during training and 1.2% (SD=0.9%) during competition. Males had significantly higher sweat rates and fluid intakes in competition compared to training and weight training. Overall, when compared to other sports, male and female soccer players had the lowest mean fluid intake and highest level of dehydration.

In a Brazilian study by De Sousa et al. (2008), authors also reported the mean water intakes (all water from food, beverages and drinking water) as determined by 4 day (n=107) or 2 day (n=219) food records. The total water consumption of both male and females across all sports was 2.8L/day. When compared to the adequate intake values, males (n=204) had a mean intake of 2.9L/day compared to the recommendations of 2.4L/day (9-13 years) and 3.3L/day (14-18 years). In the female athletes (n=122), mean intake was 2.7L/day which is higher than the range of 2.1L/day – 2.3L/day for respective age groups. Although athletes appear to meet fluid needs, the study failed to report fluid intake by sport group, so it is unclear of the specific intakes of soccer athletes.

Mao, Chen & Ko (2001) studied the sweat and electrolyte loss in order to determine iodine deficiency in 13 male Taiwanese high school senior soccer athletes to
100 controls (16-18 years). Sweat rate (before and after 4 days training) as well as the potassium, calcium, sodium iodine was tracked in both sweat and urine. Investigators revealed higher sweat and electrolyte losses in athletes versus controls, 38.5% of soccer athletes had low urine iodine compared to controls and 46% of athletes had grade 1 goiter versus 1% of controls. Over 4 days, there was a 2.5% loss of body weight reported in athletes, which was attributed to dehydration from training. This study was limited by the small sample size and a sample that represented a sub-elite level of athlete. It is well known that sweat rate can be influenced by level of training, with higher rates seen in less trained athletes (Sawka et al. 2007).

Mjannes, Horswill & Stover (2006), studied the impact of age on sweat rate in elite youth soccer players. Thirty-nine youth soccer players (19 females, 20 males) from an elite California soccer club were divided into three age groups (11 y, 13 y and 16 y). Height, skinfold measurements and pre- and post-practice body weights and fluid intake was measured during practice. Sweat rates increased with increasing age among adolescent athletes (range: 525 to 761 ml/hour). Weight, surface area and fat-free mass all increased with age and males appeared to lose significantly more sweat per kg of body weight per hour than females in the younger two groups. Although a compelling report, complete details of the study are yet to be published from this conference abstract presented at the 2006 American Medical Society for Sports Medicine Annual Meeting.

Rico-Sanz et al. (1996), investigated the effects of hyperhydration on total body water, temperature regulation and performance in 8 male elite soccer players (17+/0.6 years old) who were members of the Puerto Rico National team. Players were randomly allocated to a week of voluntary hydration (VH) and a week of hyperhydration (HH) prior to a soccer match, played in hot environmental conditions. When comparing the two groups, total body water (TBW) significantly increased in HH, and this group had lower level maximum heart rate levels. When the environmental conditions were taken into consideration, the increase in core temperature during the match rose, as a function of the heat stress index, only in VH. There were no significant differences in sweat losses, core temperature, plasma volume or performance assessment measures. The data suggest that additional water intake in these heat-acclimated players increased body water reserves and improved temperature regulation during a soccer match with no significant effect on
the decrement in soccer specific performance.

There has also been interesting hydration research in non-soccer adolescent populations. In a well controlled simulated duathlon study in the laboratory, the self selected fluid intake practices of 32 junior elite triathletes in two age groups was assessed (Iuliano, Naughton, Collier & Carlson, 1998). Athletes in the older age group were 15-17 years (males=9, females = 8) and athletes in the younger age group were 12-15 years (males = 7, females = 8). Pre and post duathlon body mass losses during exercise, fluid consumption type and quantity were measured. Significant reductions in body weight were found post duathlon in all athletes with the greatest losses in the oldest group of males (1.95% body mass loss per hour). Additionally, rates of fluid intake were approximately 490ml/hour and 255 ml/hour for the older males and females respectively and 370ml/hr and 320ml/hour for the younger males and females respectively. When comparing results to adult hydration recommendations, no participant consumed adequate intake to prevent dehydration.

In a recent Canadian study, the sweat rate, salt loss and fluid intake of 44 junior elite hockey athletes (mean age 18.4 years) during an intense on-ice practice was assessed (Palmer & Spriet, 2008). Over 50% of athletes began practice in a mildly hypohydrated state (urine specific gravity <1.020). Sweat rate during practice was 1.8L/hr with 33% of athletes losing greater than 1% of body mass and total sodium losses were 54.2moml/L. This study demonstrated that large losses of sweat and sodium and thus increased risk of complications related to dehydration is possible in ice hockey, which is played in a cool environment. Although participants were in their final year of “adolescence”, this study demonstrated that male athletes were sweating at similar rates to adult males reported in other sports.

In a recent study by Kilding et al., (2009), pre-practice hydration status (determined by urine specific gravity), body mass losses, sweat rate, fluid intake and sweat sodium losses was investigated in 13 adult (23 ± 5 years) female soccer athletes that were members of the New Zealand National squad. Assessment took place before two (T1, T2) evening training sessions (90mins) in a cool environment (T1 = 6, T2 = 14°C, Relative Humidity T1 = 71%, T2=74%). Players presented to practice in a hydrated state (USG = 1.014± 0.005, 1.011± 0.005), had low sweat rates (0.5 ± 0.2 l/hr,
0.4± 0.1L/hr) as well as low percent body mass losses (0.6± 0.5%, 0.5± 0.4%). Sodium losses were also low with mean losses being 43.9± 13.8mmol/L, 46.2± 7.9mmol/L for T1 and T2 respectively. This was the first descriptive study to report losses in female athletes. The authors concluded that athletes were at low risk for dehydration overall.

Maughan at al., (2004, 2005) and Shirreffs et al., (2004), reported the sweating response (fluid and electrolyte intake and losses) in elite male players in the heat and cool temperatures. Maughan et al., (2004) assessed the fluid balance and electrolyte losses in 24 adult male players from the English Premier League during one training session (90mins) in warm temperatures (24-29°C), and moderate humidity (46-64%). The authors reported large inter-athlete variability of sweat (sweat loss = 2033±413ml, % dehydration = 1.37±0.54%) and electrolyte losses (sweat sodium loss = 49±12mmol/L; potassium = 6.0±1.3mmol/L; chloride = 43±10mmol/L). Voluntary fluid intake (971±303ml) was also variable between players and generally insufficient to match fluid losses. Shirriffs et al., (2005) investigated similar variables in 26 male professional players during one preseason training session (90mins) in warm temperatures (32±3°C) and moderate humidity (206±5%). They reported high sweat losses (2.2±0.4L), percent dehydration (1.6±0.6%), and similar fluid intake (972±335ml) to Maughan et al., (2004). Sweat sodium losses were (30.2±18.8mmol/L) and drinking employed by players meant that only 23±21% of sodium was replaced. Maughan et al., (2005) investigated fluid and electrolyte balance in elite male (n=17) Dutch Premier Division professional players training (90 minute session) in a cool environment (5°C, 81% RH). These researchers found sweat loss (1.7± 0.5L) and sodium loss (42±13mmol/L) to be similar to warm environments, however players consumed less fluid than in warm conditions (1.0± 0.3L). Authors from all three studies conclude that regardless of temperature, players generally are not replacing their losses and due to the large inter athlete variability in fluid balance and electrolyte losses, individualization of the team’s fluid strategy is essential.

**Fluid Guidelines for Soccer Athletes**

When considering daily fluid needs for health, recommendations for non-athlete adolescents are described in the Dietary Reference Intake’s adequate intake (AI) values for fluid (Otten, Hellwig & Meyers, 2006). When a recommended daily allowance is not available for a nutrient, the AI can be used as the goal for an individual's intake.
According to these guidelines, males between 14-18 years old should consume 3.3L/day of total water, which is defined as all water contained in food, beverages and drinking water. Adequate intakes for female adolescents are 2.3L/day total water.

The US Soccer Federation has created youth heat stress guidelines for fluids that follow recommendations from the American Academy of Paediatrics policy statement on heat stress (US Soccer Federation, 2006). Fluid intake recommendations suggest:

1. **Before activity, child should be well hydrated having consumed 375ml -500ml of fluid 30 minutes ahead of time.**

2. **Drinking to be enforced periodically and every 20 minutes, 156ml of fluid consumed (player weighing 41kg or less) and 281ml fluid consumed for a player weighing 41kg or more.**

3. **Post activity hydration should continue for every 20 minutes for one hour.**

The US Soccer federation and AI guidelines are general reference ranges and should be applied with caution as sweat rate is individual and can vary according to sex, weight, height, age, temperature, physical conditioning, genetics as well as player position (Sawka et al., 2007). According to the 2007 American College of Sport Medicine (ACSM) Position Stand on Fluid Replacement, which provides hydration recommendations for adult athletes, in order manage hydration, customized fluid replacement programs that prevent excessive (<2% body weight reductions from baseline body weight) dehydration is the best means of managing hydration needs (Sawka et al., 2007). Guidelines recommend that athletes’ hydration prior to exercise should be 5-7ml/kg for the first 4 hours followed by ~3-5ml/kg in the 2 hours before exercise (Sawka et al., 2007). During exercise, fluid intake customised to prevent >2% body weight losses is recommended and post activity, ~1.5L of fluid is recommended to be consumed for each kg body weight lost (Sawka et al., 2007). ACSM advocates for the measurement of pre and post exercise body weights in order to determine sweat rates, thus allowing for customized fluid replacement programs to be created (Sawka et al., 2007).

**Nutrition Research in Soccer Athletes**

Much of the published nutrition literature describing the dietary intake and practices of adolescent elite soccer athletes is in male athletes with some literature available in adult female elite players. Research has demonstrated that athletes are at risk
for under consuming energy, carbohydrate and fibre as well as critical micronutrients such as vitamin A, vitamin E, vitamin D, vitamin B6, B5, magnesium, folate, calcium and zinc (Garrido, Webster, & Chamorro, 2007; Iglesias-Gutiérrez, García-Rovés, Rodríguez, Braga, Garcia-Zapico, & Patterson, 2005; Leblanc, Le Gall, Grandjean, & Verger, 2002; Ruiz, Irazusta, Gil, Irazusta, Casis, & Gil, 2005; Martin, Lambeth, & Scott, 2006; Mullinix, Jonnalagadda, Rosenbloom, Thompson, & Kicklighter, 2003; Clark, Reed, Stephen, & Armstrong, 2003).

In a 3-year study by LeBlanc et al. (2002), the nutrition status of 180 male junior elite soccer players (13-16 years old) training at the Clairefontaine National training centre in France was assessed. 3 cohorts of athletes (divided by age and level) were assessed at the beginning of each year. Players completed a 5-day food record (3 weekdays and 2 weekend days), using estimated household measures aided by a dietitian. After computerized dietary analysis, energy, protein, fat, carbohydrate and iron intake were compared to recommended levels for French sedentary boys of the same age group. Mean energy (intake = 2532 +/- 454kcal/day; recommendation = 3395 +/- 396 kcal/day), carbohydrate (intake = 48-56%; recommendation = 55-60% of total intake) and calcium (5 of the 9 groups) intake was below recommendations. Protein, iron and fat intakes were higher than recommendations. All athletes lived at the centre during the week and went home on the weekend. Investigators did not compare diets by food environment, so it was unclear if there was an impact of this variable on nutrition status of the athletes.

Iglesias-Gutierrez et al. (2005), studied the food habits and nutritional status of 33 male junior elite soccer players (14-16 years old) playing in the Spanish First Division Soccer league. Body composition, daily activity, hematological analysis, performance assessment and dietary intake (6-day weighted food records and eating behaviour questionnaire) were assessed. All players were living and eating at home with family. Mean energy, protein and lipid intake was reported as adequate compared to DRI’s. 100% of all athletes did not meet carbohydrate requirements (>55% carbohydrate of total calories), and intake of folate, magnesium, calcium, vitamin E and zinc were all below recommendations. Hematological results revealed ferritin levels were below reference ranges in 48% of athletes. This study acknowledged that reporting bias may have
occurred, as parents were involved in the meal preparation and influenced food intake. Despite this potential bias which may have changed normal intake, athletes did not meet many of their critical nutrient requirements.

In an early study by Rico-Sanz et al., 1998, the nutrition and performance status of eight elite male soccer players (17+/- 2 years old) on the Puerto Rico Olympic Team was investigated. 12-day food records were kept over a 2 week period in the month preceding Olympic qualifying matches and were analyzed by diet analysis software. All macronutrient needs were met by all players as compared to recommended daily intakes. Micronutrient needs were below recommended intakes for vitamin A and calcium. The interpretability of the finding from this study is difficult as authors failed to report the food environment in which the athletes were eating within, which may have impacted intake. It is also unclear if the competition environment (month before Olympics) and context of the study may have influenced athletes intake and food reporting behaviours.

Garrido, Webster & Chamorro (2007), studied differences in nutrition intake in 62 Spanish male elite soccer athletes (13-19 years) when athlete were fed a buffet style diet where meals were self chosen (n=33) or a menu style diet with no choice (n=29). Five day food intake (4 weekdays and 1 weekend match day) was measured by the principle investigator via a digital scale during meal times accounting for waste. Snacks were self reported and a food frequency questionnaire was also evaluated. Mean intakes were compared to the DRI values and American Heart Association recommendations for fat intake. Carbohydrate and energy intakes were higher in the menu compared to buffet style diet, however carbohydrate intake still fell below recommendations (mean intake <6.0g/kg) for both menus. All athletes consumed high fat intakes (mean intake >35% of total calories) and higher than recommended intake of saturated fat (13-15% of total fat). Fibre intake failed to reach adequate intake and mean micronutrient intake for folate, vitamin A, vitamin E and magnesium failed to meet DRI’s in both menus. Calcium and vitamin D were met with buffet, but not with menu. This study provides valuable evidence to support the notion that junior athletes are unable meet nutrition needs when eating away from home, which is typical during travel for competition and sport academy/residency programs.
A recent study by De Sousa et al. (2008), investigated the nutrient and water intake among a younger cohort of both male and female adolescents (11-14 years) across sport federations in the Federal district of Brazil. 326 athletes provided 4-day (n=107) or 2 day (n=219) food record (household measure method) and 24 hour recalls over two data collection periods in 2003 and 2004. Athletes were categorized as endurance (n=49, swimming, and athletics), strength-skill (n=109, gymnastics, judo, tennis and volleyball) and mixed (n=168, football, indoor football, handball and basketball). Food and fluid intake was analyzed with computerized nutritional analysis and compared to DRI’s and the Brazilian food pyramid. Although all male and female athletes met energy, fat and protein needs, females in mixed and strength skill sports failed to meet carbohydrate recommendations. Vitamin B, folate, magnesium, phosphorus, calcium and fibre were all below recommendations, with females having lower intake than males. This study, although in a pre-adolescent aged athlete, demonstrates that female soccer athletes are also at high risk for not meeting nutrition requirements and may actually be at higher risk than males for not meeting recommendations.

Martin et al., (2006) assessed nutrition intake of 16 female adult (25.5± 3.9 years) International players in England using 7-day food records. They reported that athletes appeared to be in energy balance, with low energy intake (1904 ± 366.3kcal) compared to recommendations, however not significant from expenditure (2153.5±596.2kcal). Mean intake of carbohydrate (53.8±6.8%), protein (16.8±2.1%) and fat (28.8±6.6%) were within recommended ranges, however relative intake of carbohydrate was 4.1± 1.0 g/kg, which is below relative intake recommendations. All intakes of micronutrients were within recommendations with the exception of vitamin A and iron which were 56% and 82% less than Recommended Daily Intake levels respectively.

The dietary intake of 11 adult female (19.2±1.1 years) soccer players (U21 American team) was assessed in a pilot study by Mullinix et al., (2003) using a 3-day food recording protocol as well as questionnaire regarding medical history, body image, supplement usage and attitudes towards sports nutrition practices. Mean energy intake was 2015kcal/day, with intake of carbohydrate (55%), protein (15%) and fat (30%) falling within normal ranges. Relative intake of carbohydrate was 4.7g/kg and below sport nutrition recommendations for soccer. In addition mean intake of vitamin E, D,
folate, calcium magnesium, phosphorus and zinc were less than 100% of Dietary Reference Intake values. Authors conclude that players should be encouraged to consume small carbohydrate and nutrition dense meals, frequently, and provided nutrition counselling.

In an interesting study by Clark et al., (2003), the pre and post season dietary intake (3-day food records + 24 hour recall), body composition (hydrostatic weighing) and performance indices (VO\(_2\)peak, 20yard shuttle run, vertical jump) of 13 adult female (19.7±0.7 years) NCAA Division 1 soccer players was assessed. No difference in body composition was seen between preseason (16.4±2.4% body fat) compared to post season (16.1±2.8% body fat) levels and only VO\(_2\)peak values were significantly different in the post season. Relative mean energy intakes were higher in the pre-season (37.0±5.0kcal/kg) when compared to the post season (30±18.0kcal/kg). Mean relative intake of carbohydrate was higher in the pre season (5.3±1.1g/kg) and less (4.3±0.3g/kg) in the post season, with authors suggesting intakes were lower than recommendations of carbohydrate intakes of 7-10kg/kg. Lower post season intakes of protein were also found (pre=1.4±0.3g/kg, post=0.96±0.3g/kg), with increased fat consumption in the post season (31.0±6.6%), compared to preseason (29.0±5.7%). Mean fibre intake was 58% and 53% of Adequate Intake recommendations in pre and post season respectively. In addition, mean intakes of less than 75% of the DRI values were found for vitamin E, D, folate, biotin, B5 (pre and post season) as well as calcium, chromium, iron, selenium, zinc and vitamin C (post season).

**Other Nutrition Research in Female Athletes**

The majority of nutrition research available in the female adolescent athlete population has focused primarily in sports which emphasize a lean physique or weight class such as figure skating, gymnastics, swimming and judo (Jonnalagga, Benardot, & Nelson, 1998; Farajian, Kavouras, Yannakoulia, & Sidossis, 2004; Papadopoulou, Papadopoulou, & Gallos, 2002; Kim, Kim, Kim, & Park, 2002; Hassapidou, Valasiadou, Tzioumakis, & Vrantza, 2002). Key literature that has assessed the dietary intake in this population is summarized in Table 13.
Table 14

Summary of Dietary Intake Research in Elite Female Athletes from a Variety of Sports

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<thead>
<tr>
<th>Reference Country</th>
<th>N (sex)</th>
<th>Sport (n)</th>
<th>Method of Diet Analysis</th>
<th>Summary of Macro and Micronutrient Inadequacies Reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heaney at al., 2010 Australia</td>
<td>72</td>
<td>Cycling (10); Netball (10); Softball (14); Track (9); V.ball (8); Waterpolo (21) 15-24</td>
<td>Food Frequency Questionnaire (FFQ)</td>
<td>- 65% of sample consumed &lt;5g CHO/kg&lt;br&gt;- Mean intake &lt; RDI/AI for folate (90.2 ± 41.5%), Vitamin D (56.9± 54.1%)&lt;br&gt;- In individuals, &lt; EAR &amp; RDI for folate (24%, 70%), calcium (24%, 36%), magnesium (20%, 35%). Iron (51%), Vitamin C (1%), A (10%), E (17%).</td>
</tr>
<tr>
<td>Farajian et al., 2004 Greece</td>
<td>27F, 31M</td>
<td>Swimmers (31) Water Polo (27) 21 ± 4</td>
<td>24 hour diet recall &amp; FFQ</td>
<td>- 100% &lt;5g CHO/kg&lt;br&gt;- In individuals, &lt; DRIs for Magnesium (85%), Iron (67%), Calcium (52%), Vitamin D (67%), antioxidants (93%), and B-complex vitamins (41%).</td>
</tr>
<tr>
<td>Kim et al., 2002 Korea</td>
<td>33F</td>
<td>Judo (18) Control (15) 20 ± 0.0</td>
<td>3-day Food Record</td>
<td>- Mean intake &lt; RDA for Calcium (84%) and Iron (68%)&lt;br&gt;- Individual data relative to recommendations, and macronutrient intake per kg body weight was not reported.</td>
</tr>
<tr>
<td>Jonnalagadda et al., 2002 USA</td>
<td>33F</td>
<td>Artistic Gymnastics 15.1 ± 1.3</td>
<td>3-day Food Records</td>
<td>- Mean intake &lt; RDA for Vitamin E (20%), Calcium (90%), Phosphorus (95%), Magnesium (83%), Zinc (97%), and copper (93%).</td>
</tr>
<tr>
<td>Hassapidou et al., 2002 Greece</td>
<td>15F, 20M</td>
<td>Swimmers 15-18</td>
<td>7-day Food Records (weighted)</td>
<td>- Females: Mean CHO 4.8±1.6g/kg&lt;br&gt;- Mean intakes were above RDA, however authors report individual athletes with lowest energy intakes (n not disclosed), had &lt; recommended intakes for Vitamin B1, B2, Calcium, iron and zinc.</td>
</tr>
<tr>
<td>Papadopoulou, et al., 2002 Greece</td>
<td>65 F</td>
<td>Volleyball 14-19</td>
<td>3-day food record</td>
<td>- Low intake of CHO (45.9%), high fat intake (37.5%) and adequate protein intake (14.7%) compared to DRIs.&lt;br&gt;- Mean intakes below DRI for vitamin A, B1, B2, B6, calcium, iron, folic acid, magnesium and zinc.</td>
</tr>
</tbody>
</table>
Nutrition Guidelines for Junior Elite Athletes

According to the dietary reference intakes (DRI’s) for healthy, non-athletic adolescents (14-18 years), nutrition needs are highest during this phase of the lifecycle (Otten, Hellwig & Meyers, 2006). The majority of macro and micronutrient requirements rise to adult levels during this phase of the lifecycle. In addition, adolescence marks the highest nutrition needs for protein (RDA males = 0.85g/kg/day, females = 0.85g/kg/day), calcium (RDA females/males = 1300mg/day), iron (RDA males = 11mg/day) and zinc (RDA males = 11mg/day, females=9mg/day), phosphorus (RDA males/females = 1250mg/day), magnesium (RDA males= 410mg, females = 360mg/day). When examining Canada’s Food Guide to Healthy Eating, food guide servings for males and females between 14-18 years old increase to adult levels for all food groups, and servings from milk and alternatives are at highest levels (3-4 servings/day).

Sport nutrition guidelines for adult athletes in team sports (intermittent activity), recommend increased macronutrient intake in order to support training, recovery and performance (Rodrigues, DiMarco & Langley, 2009). Suggested recommended intakes for soccer athletes include 47-60kcal/day energy (Martin et al., 2006), 5-7g/kg carbohydrate (recovery from moderate training of low intensity and duration) (Rosenbloom et al., 2006; Burke et al., 2004), and 1.2-1.7g/kg/day for protein (Rosenbloom et al., 2006; Tipton et al., 2004; Lemon 1994; Boisseau et al., 2007, 2002).

Dietary recommendations specific to junior elite athletes is currently unavailable and it is not known if the DRI’s, Canada’s Food Guide and adult sport nutrition recommendations are appropriate for this population or if any increased needs are faced by junior elite athletes (Burke & Deakin, 2007). Due to the absence of nutrition guidelines for this unique population, most research will use the DRI’s, the Food Guide, adult sport nutrition criteria and studies in similar populations are most commonly used to assess the adequacy of nutrition intake (Burke & Deakin, 2007).

Supplement Use in Junior Athletes

There is a small, growing body of research describing the prevalence of supplement use in junior elite athletes. In a very recent study by Braun, Koehler, Geyer, Kleinert, Mester, & Schänzer (2009), 164 elite young athletes (16.6 ± 3.0 years of age) from a variety of sports across within the German Olympic Sports Confederation
completed a 5-page questionnaire designed to assess their past and present (last 4 weeks) use of vitamins, minerals, carbohydrate, protein, and fat supplements; sport drinks; and other ergogenic aids. 80% of all athletes reported using at least 1 supplement, and the prevalence of use was significantly higher in older athletes. Among supplement users, minerals, vitamins, sport drinks, energy drinks, and carbohydrates were most frequently consumed. Only a minority of the athletes declared that they used protein/amino acids, creatine, or other ergogenic aids. In young U.S. figure skaters (mean age: males 16.9 years, females 15.2 years) dietary supplement use was reported to be 65% for male and 76% for female athletes (Ziegler, Nelson, & Jonnalagadda, 2003). Athletes reported they most often used multivitamins, protein powders, energy bars and herbal supplements like echinacea.

In a cross sectional study of Canadian high-performance athletes representing 27 sports with a mean age of 19.96 ± 3.91 years (314 male, 268 female), athletes completed a validated questionnaire assessing dietary supplement practices and opinions by recall. (Erdman, Fung, Doyle-Baker, Verhoef, & Reimer, 2007). There was extensive dietary supplement use, with 88.4% of participants taking >=1 dietary supplement (mean of 3.08 ± 1.87 supplement per user) during the previous 6 months. Overall, sport drinks (22.4%), sport bars (14.0%), multivitamins and minerals (13.5%), protein supplements (9.0%), and vitamin C (6.4%) were most frequently reported. Older athletes were significantly more likely to report greater usage and there were no difference in gender for usage. Although an excellent benchmark of supplement use and practices in Canadian adult athletes, there remains little Canadian information related to junior elite athletes’ usage of dietary supplements.

**Summary**

Adolescence is a unique time in the lifecycle where increased needs for nutrition and hydration are required for growth and development. The adolescent athlete has the unique challenge of also having to meet the specific nutrition and hydration demands of their sport. Female adolescent athletes are at greater risk than males for suboptimal iron status, energy and carbohydrate intake and are at greater risk for the female athlete triad syndrome which encompasses menstrual dysfunction, loss of bone mineral density as well as disordered eating. Soccer is a high intensity, intermittent sport whereby
inadequate intake of fluid, carbohydrate and energy can have negative impacts on performance. In general, soccer athletes are not meeting energy, fibre and carbohydrate needs as well as a variety of micronutrients. In addition, soccer athletes are also not consuming adequate intakes of fluid and electrolytes to replace losses and have large inter-individual variation between athletes. Soccer nutrition and hydration research conducted to date has mostly encompassed adult male and female players with some available research in adolescent male athletes. There is a paucity of data available in the female elite player.
Appendix B
Consent Form – Participants and Parents

Information Letter/Consent Form
Nutrition and Hydration Status of Junior Elite Soccer Athletes

You are being invited to participate in a study titled: Nutrition and Hydration Status of Junior Elite Soccer Athletes (Ethics Approval Protocol #10-038). This study is being conducted by Jennifer Gibson, Catherine Gaul and Lynneth Stuart-Hill and will be taking place at the Pacific Institute for Sport Excellence in Victoria, BC.

Jennifer Gibson is a Registered Dietitian and graduate student at the University of Victoria. Dr. Lynneth Stuart-Hill and Dr. Catherine Gaul are professors in the department of Exercise Science, Physical and Health Education at the University of Victoria.

Please review this information letter. You may contact Jennifer if you have further questions by e-mailing jcgibson@uvic.ca or calling her at 250-208-1300.

About the Study

The purpose of this research project is to assess your nutrition and hydration status.

Research of this type is important because it will help give you information on your nutrition, and hydration status and identify areas for improvement. It will also help develop nutrition recommendations for sport nutrition professionals who work with junior elite athletes.

You are being asked to participate in this study because you are a junior elite soccer athlete between the ages of 14 and 18 playing soccer in BC. If you agree to participate in this research, you will be asked to do the following over a 2-week time period:

a. Have a body composition assessment where 7 skin folds will be taken.

b. Fill out a nutrition assessment questionnaire and record all food and drinks that you have consumed for 4 days. You will track your food and drinks over 2 training days, 1 rest day and 1 competition day.

c. Provide the following samples three times to assess your hydration status (at 2 training sessions and 1 game): your body weight before and after soccer; a urine sample and a sweat sample.

d. Provide a blood sample. You will need to go to a local medical lab to have your blood taken. You will receive a requisition from a medical doctor to have a blood sample taken at an independent lab close to your home. This will not be conducted by study investigators.

The food logs and nutrition questionnaires will be analyzed using computerized diet software and compared to recommendations by Health Canada and Canada’s Food Guide. The sweat loss and urine information will be used to calculate sweat rates and hydration status. Your sweat will be analyzed for sodium (salt) losses. Your blood will be analyzed for full hematology panel, differentials, (measures that your doctor normally assesses for your cell counts and immune system) vitamin D and iron levels.
Participation Risks/Benefits

Participation in the study should not cause a major inconvenience to you, however you may experience some low level risks associated with participating in this study.

Since you will need to give a urine sample, this may cause slight embarrassment when discussing this or while you are collecting your urine and providing it to study investigators. You will collect urine in private toilet stall and will be asked to leave the urine sample in a separate area outside of the washroom, similar to what you would do at a doctor’s office. Study investigators will stay away from the toilet area, to reduce any associated anxiety or embarrassment with providing a urine sample.

Secondly, you may experience slight discomfort during the skinfold measurements, since your skin needs to be slightly, yet gently, pulled and pinched for a few seconds.

Lastly, there are potential physical risks associated with having blood taken. While rare, these include problems locating the vein/artery for puncture, fainting or light-headedness, hematoma (bruising) and infection. The overall risk of these is small, particularly since professional health care workers with expertise in this area will be conducting these blood samples.

If you do not feel comfortable providing any of the above-mentioned samples, you do not have to do so.

There are a number of benefits that you may experience by participating in this study. First, we anticipate and fully intend that participation in the study will be fun for you. In addition, you will receive the results from this study and feedback on your nutrition and hydration within 2 months of the testing, which can be valuable information to help with your current training diet and hydration for soccer training.

Additional Information

There is no compensation for participation in this study. However, it is the opinion of the researchers that there is tremendous value in having the nutrition and hydration assessment.

Your participation in this research must be completely voluntary. Your position on your team will not be affected if you choose to not participate in this study. If you decide to participate, and then change your mind, you may withdraw at any time without any consequences or explanation. If you withdraw from the study, your data only be used with your consent. If consent is not given, it will be destroyed immediately.

Your anonymity will be protected in this study. No identifying information (i.e. name) will ever be stored/presented after the study is completed. With your consent, pictures will be taken during the testing. At the bottom of the consent form, you have the option to have your images used in the presentation of the findings of this research (such as at conferences or in publications, and to interested professionals). If you would only like your image to be viewed by the research team and never used in presentation, just tick the “No” box and your image will never be used.

It is anticipated that the results of this study will be shared with others by publication in a scholarly journal and presentation at conferences/meetings in the future. Information from this study will be disposed by shredding paper data and electronically deleting images after five years.

In addition to being able to contact the researcher at the above e-mail address, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Associate Vice-President, Research at the University of Victoria (250-472-4545).
Athlete Consent to Participate in Study

Your signature below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

_____________________________  __________________________  __________
Name of Participant               Signature of Participant               Date

_____________________________
Participant Phone number

_____________________________
Participant Email Address

I agree to have my images used in the presentation of the results of this study.

☐ Yes  ☐ No

_____________________________
Signature

Parent/Guardian Confirmation of Awareness

It is important that your parent(s)/guardian are aware and informed of your participation in this study. Your confidentiality will be maintained and your individual results will only be provided back to you.

The signature of your parent/guardian below indicates that they are informed and aware of your participation in this study.

_____________________________  __________________________  __________
Name of Participant               Signature of Participant               Date

_____________________________
Parent/Guardian

_____________________________
Participant Parent/Guardian Phone number (emergency purposes only)

_____________________________
Participant Parent Guardian Email Address (emergency purposes only)

A copy of this signed consent page will be provided back to you, and a copy will be taken back to the University of Victoria
Appendix C
Nutrition Questionnaire and Food Recording Sheets

Nutrition and Hydration Status of Junior Elite Soccer Athletes
Protocol No. 10-039
Investigators: J. Gibson, C. Gaul, L. Stuart-Hill

PLAYER CONTACT INFORMATION:

PLAYER ID number (do not fill out): 

<table>
<thead>
<tr>
<th>Player’s Name</th>
<th>Date of Birth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home Address</td>
<td></td>
</tr>
<tr>
<td>Phone</td>
<td>FAX</td>
</tr>
<tr>
<td>Mobile phone</td>
<td>Email</td>
</tr>
</tbody>
</table>

2. MEDICAL HISTORY (e.g. Injuries, Stress fractures, low iron/anemia, kidney, heart, diabetes etc.):

<table>
<thead>
<tr>
<th>Type</th>
<th>Dates</th>
<th>Details</th>
</tr>
</thead>
</table>

3. MENSTRUAL HISTORY

3a. Do you currently get a regular [every month] menstrual period?
- Yes
- No
Additional Comments:

3b. Have you ever missed your period for more than 3 months?
- Yes
- No
Additional Comments:

3c. What was the date of the start of your last period?
I started my last period on: Date/Month/Year: 

3d. How many days do your periods usually last?

4. FOOD ALLERGIES / INTOLERANCES:

Do you have a food allergy / intolerance or special diet practice (e.g. vegetarian/vegan):
- YES
- NO
Specify allergy and symptoms:
5. BIOCHEMISTRY:

<table>
<thead>
<tr>
<th>Have you ever had a blood test that identified you had the following nutritional deficiencies:</th>
<th>YES</th>
<th>NO</th>
<th>Dates and Details:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5a. Iron Deficiency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5c. Vitamin B12:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5d. Other:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. MEDICATIONS & SUPPLEMENT USE:

<table>
<thead>
<tr>
<th>Are you currently taking any prescription medications or supplements [i.e. multivitamins, iron pills, herbs, caffeine, creatine, amino acids] or other dietary supplements. Please list:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of medication/supplement</td>
</tr>
<tr>
<td>--------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

7. NUTRITIONAL SUPPORT:

<table>
<thead>
<tr>
<th>7a. Have you ever worked with a nutritionist or dietician?</th>
<th>Yes</th>
<th>No</th>
<th>If yes, list name and location:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7b. Do you shop for and prepare all of your own meals?</td>
<td>Yes</td>
<td>No</td>
<td>If no, who does:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7c. Do you eat out at restaurants or fast food outlets?</td>
<td>Yes</td>
<td>No</td>
<td>If yes, how often and what restaurants are your favorite?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8. CURRENT TRAINING SCHEDULE: Include: TIME, TYPE, DURATION and INTENSITY of training in the week

**Eg. Monday: 8:00am Phys Ed/60mins/Volleyball**

<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
<th>Sunday</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### SPORT NUTRITION HABITS:

#### 9. Pre-TRAINING Hydration/Eating Plan

<table>
<thead>
<tr>
<th>If yes,</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you drink?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How much do you drink?</td>
<td>m/L</td>
<td></td>
</tr>
<tr>
<td>When do you drink it? (e.g. 10 mins before)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 8b. Do you eat before practice/training?

<table>
<thead>
<tr>
<th>If yes,</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you eat?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimate the amount:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When do you eat it?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 10. Pre-GAME Hydration/Eating Plan

<table>
<thead>
<tr>
<th>If yes,</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you drink?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How much do you drink?</td>
<td>m/L</td>
<td></td>
</tr>
<tr>
<td>When do you drink it? (e.g. 10 mins before)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 10b. Do you eat before a game?

<table>
<thead>
<tr>
<th>If yes,</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you eat?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimate the amount:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When do you eat it?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
11. During Training Hydration/Nutrition

11a. Do you drink DURING practice/training?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

If yes,

What do you drink? ________________________________

How much do you drink? ___________________________m/L

When do you drink it? [eg. 10 mins before]

______________________________________________

11a. Do you eat DURING practice/training?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

If yes,

What do you eat? ________________________________

Estimate the amount: _____________________________

When do you eat it? _____________________________

12. During Game Hydration/Nutrition

12a. Do you drink DURING a GAME?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

If yes,

What do you drink? ________________________________

How much do you drink? ___________________________m/L

When do you drink it? [eg. 10 mins before]

______________________________________________

12b. Do you eat DURING A GAME?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

If yes,

What do you eat? ________________________________

Estimate the amount: _____________________________

When do you eat it? _____________________________
### 13. Post Training Hydration/Eating Plan

| 13a. Do you drink after practice/training? | ☐ Yes | ☐ No | If yes, What do you drink?  
How much do you drink? _________ mL/L  
When do you drink it? [eg. 10 mins before] |
|-----------------------------------------|-------|------|-------------------------------------------------|
| 13b. Do you eat after practice/training? | ☐ Yes | ☐ No | If yes, What do you eat?  
Estimate the amount: _______  
When do you eat it? |

### 14. Post - Game Hydration/Eating Plan

| 14a. Do you drink after a GAME? | ☐ Yes | ☐ No | If yes, What do you drink?  
How much do you drink? _________ mL/L  
When do you drink it? [eg. 10 mins before] |
|---------------------------------|-------|------|-------------------------------------------------|
| 14b. Do you eat after a GAME? | ☐ Yes | ☐ No | If yes, What do you eat?  
Estimate the amount: _______  
When do you eat it? |

### 15. Muscle cramping

| 15a. Have you ever had problems with muscle cramping? | ☐ Yes | ☐ No | If yes, How often does this happen?  
Where did the cramping occur [ie. Foot]? |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>15b. Describe the things you do to prevent muscle cramping?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***************END OF NUTRITION QUESTIONNAIRE. THANK YOU***************
FOOD RECORDING FORMS

Food Recording Instructions – PLEASE READ CAREFULLY:

1. **DON’T CHANGE YOUR EATING HABITS WHILE KEEPING YOUR FOOD RECORD.**

2. **Tell the truth.** Record what you really eat! All information collected is confidential.

3. Write down **EVERYTHING** & take your food records with you. Keep your form with you all day long and write down everything you eat and drink. (eg. candy, sport drink, crackers, can of pop).

4. **Be specific.** Include brand names of products. (eg. Kellogg’s Special K cereal vs. stating “cereal”) Make sure you include ‘extras,’ such as gravy on your meat, cheese on your sandwich or vegetables, butter, and salad dressings.

5. **Estimate amounts.** If you have a bowl of cereal, measure out or estimate the actual amount (rather than writing ‘bowl’ of cereal). Please refer to the serving size reference guide to help with this.

6. **Write legibly.** Use neat handwriting or record in book during day and type into form.

7. Using the following forms, record everything you eat and drink for 4 days.
   - 2 typical training days
   - 1 rest day, or low activity day
   - 1 competition day
Sample Form 1
(Full forms included Training Day #2, Game Day, Rest Day and Extras)

TRAINING DAY #1 FOOD and FLUID INTAKE:

Date of food record:

Describe your activity today (time, type, intensity):

<table>
<thead>
<tr>
<th>TIME</th>
<th>FOODS</th>
<th>Approx Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00am</td>
<td>Whole wheat Dempsters bagel with full fat cream cheese and Tropicana orange juice</td>
<td>1 medium bagel, 1 cup juice, 2 tablespoons cream cheese.</td>
</tr>
</tbody>
</table>

|          |                                                 |                                                   |
|          |                                                 |                                                   |
|          |                                                 |                                                   |
|          |                                                 |                                                   |
|          |                                                 |                                                   |
Appendix D
Anthropometry Data Collection Sheet

<table>
<thead>
<tr>
<th>NAME</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HEIGHT</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SKINFOLDS</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triceps</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subscapular</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biceps</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iliac Crest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supraspinale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abdominal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front Thigh</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medial Calf</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GIRTHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arm - relaxed</td>
</tr>
<tr>
<td>Arm - flexed</td>
</tr>
<tr>
<td>Waist</td>
</tr>
<tr>
<td>Hip</td>
</tr>
<tr>
<td>Calf - max</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BREADTHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humerus</td>
</tr>
<tr>
<td>Femur</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MEASURER</th>
<th>RECORDER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix E

Environmental Conditions Data Collection Sheet

**Temperature Tracking and Description of Training**

<table>
<thead>
<tr>
<th>Date of Testing:</th>
<th>Actual Time (h:min)</th>
<th>Ambient Temp (°C)</th>
<th>Relative Humidity (%)</th>
<th>Wind Speed (m.s⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 mins</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 mins</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45 mins</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60 mins</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75 mins</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90 mins</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>105 mins</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>End of Session</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Description of Session:**

Soccer Specific Conditioning (Eg. small sided team games, high intensity shuttle running drills with and w/o ball. Active rest (slow jogging), ball work)
# Appendix F

## Hydration Testing Tracking Sheet

<table>
<thead>
<tr>
<th>NAME:</th>
<th>Measurement 1</th>
<th>Measurement 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heart Rate Monitor #</td>
<td></td>
</tr>
<tr>
<td>DATE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-weight (kg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-weight (kg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deficit (weight) (kg)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Deficit volume (wt x1000 - vol in mL) (mL)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>% body Mass lost (deficit/10)/pre wt</td>
<td>#DIV/0!</td>
<td>#DIV/0!</td>
</tr>
<tr>
<td>Pre Fluid Weight (L) or (kg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post Fluid Weight (L) or (kg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluid Intake (L)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sweat Loss (Deficit + Fluid Intake) (L)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Duration (hr)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweat Rate (Sweat Loss/time) (L/hr)</td>
<td>#DIV/0!</td>
<td>#DIV/0!</td>
</tr>
<tr>
<td>USG (pre) (usg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydration Status</td>
<td>fully hydrated</td>
<td>&lt;1.015</td>
</tr>
<tr>
<td></td>
<td>mild dehydration</td>
<td>1.015-1.020</td>
</tr>
<tr>
<td></td>
<td>moderate dehydration</td>
<td>1.021-1.030</td>
</tr>
<tr>
<td></td>
<td>severe dehydration</td>
<td>&gt;1.030</td>
</tr>
<tr>
<td>Type of Beverage Consumed</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>Sweat Sodium Concentration</td>
<td>40-80mmols is normal range</td>
<td>mmol loss</td>
</tr>
</tbody>
</table>
Appendix G
Data Collection Protocol

Thesis: Nutrition and Hydration Status of Junior Elite Soccer Athletes
Student: Jennifer Gibson
Location & Dates: Pacific Institute for Sport Excellence, Victoria, BC.
March - April 2010

A. SESSION 1


1. Meeting with prospective athletes pre or post soccer practice in order to provide information on study/recruitment.

2. Interested athletes to sign information/consent form. Athletes also given a parent information letter to take home.

3. Post Practice: Anthropometry and food questionnaires will be collected and education about food recording given. Athletes will rotate through 3 “stations” where they will:
   a. Have height, weight, skin folds taken by 2-3 ISAK certified anthropometrists.
   b. Complete the nutrition information questionnaire.
   c. Be given education/instruction regarding the food recording forms and how to keep an accurate food diary by a Registered Dietitian.
   d. Data then entered into excel data collection spreadsheets by researcher.

4. All recruited athletes will be asked to present to lab 1 hour before next team practice in order for fluid balance prep. Athletes will also be emailed a reminder to do this.

5. Recruited participants data will be entered into Team Polar Heart Rate software.

6. Names of participants will be relayed to doctor in order to obtain/complete lab requisition forms for blood work.

B. SESSIONS 2 (training), 3 (training)

A. Pre-practice/Game

Before athlete arrival:
- Ensure heart rate monitor numbers have been assigned and team created in the system.
- Ensure urine collection cup and test tubes have been assigned athlete names.
- Take centre field temperature/humidity measure.
- Ensure scale is set up in change room.

1. Pre practice, athletes will arrive at the lab and will rotate through 4 stations of study preparation and data collection:
   a. Urine collection. Each athlete will have a pre-assigned cup with their name on it and will be given instructions about voiding in order to collect a sample.
   b. Sweat patch preparation. Under the direction of researcher, each athlete will clean forearms with soapy water and pat dry and will have one sweat patch applied to each forearm.
   c. Body and bottle weight. Athletes will have pre-practice body weights taken in lab bathroom. Athlete’s water bottle weight will also be taken. Note the type of fluid being consumed.
   d. Heart rate monitor. Each athlete will be assigned an individual heart rate monitor.

B. During Training Session/Game

- Researcher to take 2-3 measures of environmental temperature during session
- Researcher to check heart rate monitor system on laptop to ensure data is being collected.
- If there is time, conduct USG testing during practice

C. Post Training Session/Game

1. Post practice, athletes will return to the lab and will rotate through 3 stations of study data collection:
   a. Sweat patch removal. Under the direction of researcher, each athlete will have sweat patches removed and placed in test tube for centrifuging.
   b. Body and bottle weight. Athletes will have post-practice body weights taken in lab bathroom. Athlete’s water bottle weight will also be taken. Athletes will be requested to towel of excess sweat.
   c. Heart rate monitor removal. Each athlete will remove their individual heart rate monitor.

2. Athletes will be given their lab requisition forms for blood work with instructions. They will be reminded verbally and via email that they must have blood work conducted within the 2 week testing time frame.
3. Athletes will be asked how their food diary recording is going and reminded of 2-week deadline verbally and via email before the final date of testing.

**After athlete departure**
- Analysis of any urine sample collected before practice/game for urine specific gravity
- Test tubes inserted into centrifuge for 1 hour spin down
- Download and record mean heart rate data for the session
- Refrigerate sweat sodium samples and conduct analysis the following day
- Enter all data into excel spreadsheets

**Sweat patch Location and Preparation (Patterson et al, 2000)**

1. Chest (superior to the nipple and ~5cm lateral from the sternum)
2. Scapula (over spine of scapula and ~7cm lateral from the vertebral column)
3. Forearm (mid-dorsal)
4. Thigh (mid-ventral)
5. Low Back (5cm lateral from vertebral column)

**PREP:**
- Skin thoroughly washed using de-ionized water and dried
- to prevent sweat evap, upper surface of patch was covered with a thin, non-porus adhesive film? Not sure what this is?
- placement was anatomically marked so placement during T1 and T2 was identical
- mean whole body values were calculated from reg. equ's from Patterson
Appendix H
Participants Results Form

About Your Results

Thank you for your participation in this study! A total of 34 junior elite soccer athletes from U18, U16 and U14 groups participated in the study. Your personal results and the study averages (all participants) are summarized in this report. Where applicable, available recommendations are also provided.

Hydration testing and heart rate measurement occurred before and after two training sessions (T1 and T2).

Nutrition assessment was conducted using the nutrition questionnaire and 4-day food records.

If you have any questions about your results, please feel free to contact study investigators: Jennifer Gibson (jgibson@uvic.ca) or Dr. Catherine Gaul (cgaul@uvic.ca)

Hydration Testing Results

<table>
<thead>
<tr>
<th>Hydration Testing Results</th>
<th>Your Results</th>
<th>Study Average</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Practice U60+T1</td>
<td>1.858</td>
<td>4.017</td>
<td>&gt; 1.262 indicates mild dehydration</td>
</tr>
<tr>
<td>T2</td>
<td>1.033</td>
<td>3.017</td>
<td></td>
</tr>
<tr>
<td>Sweat Rate T1 (ml/hour)</td>
<td>1866.5</td>
<td>485.0</td>
<td>none</td>
</tr>
<tr>
<td>T2 (ml/hour)</td>
<td>1062.2</td>
<td>351.6</td>
<td>normal</td>
</tr>
<tr>
<td>% Body Mass Loss T1</td>
<td>2.3</td>
<td>1.0</td>
<td>&gt; 2.0% can improve performance</td>
</tr>
<tr>
<td>T2</td>
<td>2.8</td>
<td>0.6</td>
<td>&gt; 2.0% can improve performance</td>
</tr>
<tr>
<td>Average Sweat Sodium Loss (mmol/L)</td>
<td>6.0</td>
<td>4.7</td>
<td>40-80mmol/L = normal loss</td>
</tr>
</tbody>
</table>

About Hydration Results

1. *U60 (Urtha Specific Gravity)* is a marker of your hydration status. Athletes with a U60 < 1.020 should aim to consume more fluids regularly (water and/or milk are best) BEFORE exercise. Urine colour can help identify your hydration status (Light colour = hydrated; dark = potentially dehydrated). Guidelines recommend 0-7 ml/kg at least 4-hours before exercise. When urine is dark, drink 3-5 ml per kg body weight of water, milk, or sport drink about 2 hours before exercise (this is about 1 cup or 200 - 300 ml of fluid). You should aim to consistently sip fluids towards the start of practice/game using urine colour as an indicator of hydration status.

2. Percent (%) Body Mass Loss represents the amount of sweat lost and replaced during the training session. Research has shown losing more than 2.0% body mass during exercise can result in performance decrements. Athletes losing 1.0% or more, should increase their fluid intake (water, diluted juice of sport drink) consumption during exercise. Aim for 150-250ml per 20-30 mins of exercise.

3. Sweats Rate (ml/hour) represents the amount of sweat lost and replaced (through drinking) during each training session. Normal sweat rates range for adolescent female athletes have not been established yet (one of the reasons for this study). Athletes with high sweat rates combined with high percent body mass loss should aim to drink more during exercises.

4. Sweat sodium loss (mmol/L) were calculated using the sweat patches. Athletes with higher sweat sodium loss (>10mmol/L) may be at higher risk for muscle cramps and may need to consider using a sport drink with sodium in it during training and/or additional sodium (salt) during the day (e. in your foods).Seeking the help of a sport nutrition professional is advised in this case.

Nutrition Assessment Results

<table>
<thead>
<tr>
<th>Nutrition Results (grams per day)</th>
<th>Your results</th>
<th>Study Average</th>
<th>Normal Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories consumed (kcal)</td>
<td>2314</td>
<td>2074</td>
<td>See note #1 below</td>
</tr>
<tr>
<td>Calories burned (kcal)</td>
<td>2916</td>
<td>2530</td>
<td>See note #1 below</td>
</tr>
<tr>
<td>Carbohydrate (g/kg body weight)</td>
<td>75.3</td>
<td>5.0</td>
<td>Minimum of 5.5g/kg</td>
</tr>
<tr>
<td>Fibre intake (g)</td>
<td>30.2</td>
<td>25.6</td>
<td>25 g/day</td>
</tr>
<tr>
<td>End (% of total calories)</td>
<td>40.1</td>
<td>30.0</td>
<td>75 - 35%</td>
</tr>
<tr>
<td>Carbohydrates (g)</td>
<td>1659.42</td>
<td>915.09</td>
<td>1200mg/day</td>
</tr>
<tr>
<td>Vitamin D intake (ug)</td>
<td>9.42</td>
<td>4.11</td>
<td>5 ug/day</td>
</tr>
<tr>
<td>Calcium intake (ug)</td>
<td>463.69</td>
<td>273.63</td>
<td>1100ug/day</td>
</tr>
<tr>
<td>Phosphorus (ug)</td>
<td>0.58</td>
<td>4.50</td>
<td>45ug/day</td>
</tr>
</tbody>
</table>

Normal values for nutrition are based on Dietary Reference Intakes. These are recommended daily intakes for females 14-18 years old for optimal health.
Nutrition Results

1. Calories consumed and burned. A healthy body weight is the best indicator of calorie balance and heat balance over time. To assess if calorie intake is matched to output, your results reveal you are consuming just about adequate amounts of calories to meet those burned during the day and in soccer training. Great work!

2. Carbohydrate & fibre. Carbohydrates are the number one fuel source for energy in soccer athletes. Quality carbohydrates are found in fruits, vegetables, grains and milk/milk alternative products. Fibre is also found in fruits, vegetables and whole grain products. Your results reveal you are consuming adequate amounts of carbohydrate and fibre, great work!

3. Protein is essential for muscle building and repair as well as recovery after exercise. Quality sources of protein include milk/milk alternative products, lean meats, fish and meat alternatives. Your results reveal you are consuming adequate amounts of protein great work!

4. Fat is used as an excellent energy source during endurance exercise such as soccer. The majority of fat in the diet should come from plant and fish sources (nuts, seeds, salmon and olive oil) and not baked goods or junk food. Your results reveal you are consuming adequate amounts of fat, great work!

5. Calcium and Vitamin D are essential for bone health especially in female adolescents who are still developing their bone mass. Best sources of calcium and Vitamin D come from milk and milk alternatives food choices. Your results reveal you are consuming adequate amounts of calcium and Vitamin D, great work! You should aim to increase consumption of milk/milk alternative products, which contain both these nutrients. Check out the calcium calculator on the BC Dairy Foundation website to find ways to increase calcium and Vitamin D in your diet. http://bcdairyfoundation.ca/interactive/calcium-calculator/

6. Folate and Vitamin B6 are B vitamins involved in energy metabolism and are important for athletes. B vitamins are found in grain products like bread, cereals, pasta and rice. Your results reveal you are consuming the recommended range for Folate and B6, great work! Have a look at your diet in relation to Canada’s food guide. (http://www.hc-sc.gc.ca/cm-air-food-guide-american-eng.php), it recommends a minimum of 6 servings of grains per day for female teens. This requirement might be even higher in athletic female teens like you.

Blood Work Testing Results

<table>
<thead>
<tr>
<th>Blood Work Results</th>
<th>Your Result</th>
<th>Study Average</th>
<th>Normal Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum Ferritin (µg/L)</td>
<td>43</td>
<td>22.15</td>
<td>12-93 µg/L</td>
</tr>
<tr>
<td>Vitamin D, 25-Hydroxy (nmol/L)</td>
<td>412</td>
<td>75.12</td>
<td>25-151 nmol/L</td>
</tr>
<tr>
<td>Prolactin (ng/mL)</td>
<td>501</td>
<td>260.65</td>
<td>100-5500 mg/L</td>
</tr>
</tbody>
</table>

About Blood Results

Important note: Dr. Steve Martin has contacted all athletes with abnormal blood values. If you have not heard from him, your values are normal.

1. Serum Ferritin (iron) is an indicator of your iron status. Iron is crucial for female athletes as it is essential for effective oxygen delivery in the body. Female athletes should have their iron status assessed at least 1x per year. Recommendations are based on clinical ranges for non-athletes. Athletes with values below or on the low end of the normal range should consult with their family doctor, a sport medicine doctor and/or a sport dietitian for follow up.

2. Vitamin D levels may be low in Canadians due to lack of sun exposure during the winter months and increased use of sunscreen. Due to the critical role of vitamin D in bone health, vitamin D levels in the tropics should be assessed in the winter months if athletes are not having adequate exposure to sunshine. Recommendations are based on clinical ranges for non-athletes. Values < 25 nmol/L indicate a clinical deficiency and < 40 nmol/L indicate insufficient Vitamin D stores. Athletes whose values are below these levels or close to these low normal ranges should consult with their family doctor, a sport medicine doctor and/or a sport dietitian for follow up. It is also important to consider that these are results from training during March/April when the sunshine was pretty limited.

3. Prolactin is a measure of overall nutrition status. Players with low values may not be consuming adequate amounts of calories, particularly in the form of protein, which could negatively impact growth and soccer performance. Players with values below 150 mg/L should consult with their family doctor for follow up.

Body Composition Testing Results

<table>
<thead>
<tr>
<th>Body Composition</th>
<th>Your Results</th>
<th>Study Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kg)</td>
<td>70.2</td>
<td>60.0</td>
</tr>
</tbody>
</table>

About Body Composition Results

Height and weight data: There is a large range in these values due to age and maturation differences of athletes in the study. Since this is the first study to report these values in adolescent Canadian female soccer athletes, there are no current ranges against which to compare your results. There is no research to suggest an ideal height or weight for soccer athletes exists.
### Exercise Intensity Testing Results

<table>
<thead>
<tr>
<th>Exercise Intensity Results</th>
<th>Your result</th>
<th>Study Average</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Heart Rate T1 (bpm)</td>
<td>160</td>
<td>142</td>
<td></td>
</tr>
<tr>
<td>T2 (bpm)</td>
<td>128</td>
<td>157</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Time spent in different intensity zones**

<table>
<thead>
<tr>
<th>Intensity Zone</th>
<th>Time Spent (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Hard T1</td>
<td>0:01:26</td>
</tr>
<tr>
<td>T2 (minutes)</td>
<td>0:01:27</td>
</tr>
<tr>
<td>T2 (minutes)</td>
<td>0:01:27</td>
</tr>
<tr>
<td>Moderate T1</td>
<td>0:06:19</td>
</tr>
<tr>
<td>T2 (minutes)</td>
<td>0:06:19</td>
</tr>
<tr>
<td>Light T1</td>
<td>0:10:15</td>
</tr>
<tr>
<td>T2 (minutes)</td>
<td>0:10:15</td>
</tr>
<tr>
<td>Very Light T1</td>
<td>0:06:15</td>
</tr>
<tr>
<td>T2 (minutes)</td>
<td>0:06:15</td>
</tr>
</tbody>
</table>

**About Exercise Intensity Results**

1. Mean Heart Rate (bpm) represents your average heart rate (beats per minute) over the training session. The higher the value, the harder your average work rate during the practice session. Resting heart rate is usually around 60-80 beats per minute.

2. Time spent in different training zones represents the accumulated (not continuous) time spent at different training intensities.