Identifying and managing RED-S: What is the physiotherapist experience? A cross-sectional survey of Canadian physiotherapists

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A thesis submitted in partial fulfillment of the requirements for the Master of Science degree in Kinesiology
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Abstract

Relative Energy Deficiency in Sport (RED-S) is a complex condition characterized by chronic low energy availability (LEA) affecting an athlete’s health and performance. A cross-sectional, mixed-methods survey was used to investigate Canadian Physiotherapists' (PTs) experience with RED-S. Sixty-nine PTs completed the survey which assessed participants’ knowledge of RED-S, their confidence in diagnosing and managing RED-S, their exposure to RED-S in clinical practice, and their education-related experience with RED-S. Participants scored an average of 25.1 (± 4.1), (71.7%) on the knowledge section of the survey, and an average of 32.7 (± 19.4), (51.1%) on the confidence-related section. There were no significant differences between the knowledge and confidence scores based on specialty (Sports, Women’s Health, Sports and Women’s Health, Orthopedics, Other). This survey demonstrated gaps in PTs knowledge of RED-S and their confidence in treating the condition. Canadian PTs expressed a need for concise educational resources to be made available regarding RED-S.

Keywords: Relative Energy Deficiency in Sport, RED-S, Female Athlete Triad, Physiotherapy, Education
Summary for Lay Audience

Our study looked at Canadian Physiotherapists' (PTs) knowledge and experience recognizing and treating Relative Energy Deficiency in Sport (RED-S) (originally known as 'The Female Athlete Triad'). The study involved an online survey that explored PTs knowledge of RED-S as well as their confidence levels in recognizing the signs of RED-S and in managing the condition. The survey also assessed PTs exposure to RED-S in their clinical practice and in their physiotherapy training. Sixty-nine participants completed our survey. On average, PTs scored 71.7% on the knowledge section of the survey, and 51.1% on the confidence-related section. 68% percent reported that they had assessed patients with RED-S in their clinical practice. PTs expressed a need for more widespread, concise materials to be made available that could be used by clinicians to help diagnose, treat, and manage the condition and distributed to coaches and athletes to help raise awareness about the condition. Additionally, only 50.0% of PTs reported learning about RED-S in their training program, and 71.0% identified the lack of education about RED-S as a potential obstacle for treatment. While Canadian PTs knowledge about RED-S appeared adequate, their self-reported confidence levels regarding their clinical ability to diagnose and manage the condition were much lower. Knowledge of RED-S and confidence in managing the condition are essential for health care professionals to ensure early diagnosis and proper management of RED-S. Additionally, increased awareness about RED-S is needed among Canadian PTs to protect the long-term health of athletes diagnosed with RED-S and decrease its overall occurrence.
Co-Authorship Statement

Both L.J.D. Parkinson and J. S. Thornton contributed to the design of the study with input from J. M. Schulz and S. Doralp. All data was collected and analyzed by L. J.D. Parkinson with assistance during data analysis from J. M. Schulz. The original manuscript and thesis were written by L.J.D. Parkinson with helpful feedback from the co-authors.
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To every single member of the Women’s Cross Country team at Western University, I would not be who I am today without the influence that these wonderful women have played
in my life. When I finished my undergraduate degree, I was in an awful place with running, which weighed heavy on my heart due to the integral place the sport plays in my life. This team, along with our amazing coaches, Guy Schultz, Janet Takahashi, and Scott MacDonald have helped me to regain my love for this sport, which in turned brought back the peace, and love I get from it every day. This team brought me back from a very dark place and allowed me to feel like myself again, which is probably one of the only reasons I made it through this program.

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<tr>
<td>RED-S</td>
<td>Relative Energy Deficiency in Sport</td>
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<tr>
<td>IOC</td>
<td>International Olympic Committee</td>
</tr>
<tr>
<td>LEA</td>
<td>Low Energy Availability</td>
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<td>DE</td>
<td>Disordered Eating</td>
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<tr>
<td>HCPs</td>
<td>Health care professionals</td>
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<tr>
<td>EA</td>
<td>Energy availability</td>
</tr>
<tr>
<td>PTs</td>
<td>Physiotherapists</td>
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<td>ATs</td>
<td>Athletic Therapists</td>
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<tr>
<td>LEAF-Q</td>
<td>Low Energy Availability in Females Questionnaire</td>
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<tr>
<td>HPO</td>
<td>Hypothalamic-Pituitary Ovarian Axis</td>
</tr>
<tr>
<td>BSI</td>
<td>Bone Stress Injury</td>
</tr>
<tr>
<td>CPA</td>
<td>Canadian Physiotherapy Association</td>
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<tr>
<td>WHD</td>
<td>Women’s Health Division</td>
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<tr>
<td>SPC</td>
<td>Sport Physiotherapy Canada</td>
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<tr>
<td>OrthoDiv</td>
<td>The Orthopedic Division</td>
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<td>PSD</td>
<td>Pain Science Division</td>
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<td>Cardiorespiratory Division</td>
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<td>CPA Private</td>
<td>Private Practice Division</td>
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<td>PCE</td>
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Chapter 1 : Literature Review

Introduction

Relative Energy Deficiency in Sport (RED-S) is a condition recognized and supported by the International Olympic Committee (IOC) that is characterized by prolonged low energy availability (LEA), affecting optimal bodily functions and performance in sport (Gillbanks et al., 2022; Mountjoy et al., 2018). RED-S is a multi-faceted condition that can affect an athlete in many ways including by causing impairments to their metabolic rate, menstrual function, bone health, immune system, protein synthesis and cardiovascular system (Figure 1) (Mountjoy et al., 2014). LEA refers to a mismatch in the amount of energy taken in by an athlete compared to the total amount of energy that they expend in their daily life and in their sports (Statuta et al., 2017). This can be caused by intentional or unintentional insufficient caloric intake, or by excessive energy expenditure (Statuta et al., 2017).

The term RED-S was brought forward in 2014 as an update to what was previously known as the Female Athlete Triad (Mountjoy et al., 2014). The IOC first recognized the Female Athlete Triad in 2005 and at the time defined it as “the combination of disordered eating (DE) and irregular menstrual cycles eventually leading to a decrease in endogenous estrogen and other hormones, resulting in low bone mineral density” (Drinkwater et al., 1986; Mountjoy et al., 2014; Sangeenis et al., 2005). In 2007, following advancements and clinical progress in the understanding of the Triad, the American College of Sports Medicine redefined the Female Athlete Triad as the “relationship between three inter-related components, energy availability (EA), menstrual function and bone health” (Nattiv
et al., 2007). These changes were made to reflect a new understanding of the interrelationships between the three components of the Triad as well as the notion that the Triad is a spectrum that an affected athlete moves along from where they are a healthy individual with normal EA, a normal menstrual cycle and normal bone mineral density to the opposite end of the Triad where the individual is living with LEA, possible amenorrhea and low bone mineral density (osteoporosis) (Nattiv et al., 2007).

Figure 1: (a) Health consequences and (b) Performance consequences of RED-S (Mountjoy et al., 2014). An athlete with RED-S can suffer from a combination of both health and performance consequences of the condition which can continue to affect the athlete even after retirement from sport (Mountjoy et al., 2014). These figures demonstrate the complexity and severity of RED-S and help to highlight why diagnosing the condition can be difficult.
Physiological and Performance Consequences of RED-S

The 2014 retitling of the Female Athlete Triad to RED-S reflected an increase in the scientific understanding of the physiology behind the condition and what the affected athletes were experiencing (Mountjoy et al., 2014). It became clear that the consequences of an athlete living in a state of prolonged energy deficiency extended beyond the three entities of the Triad (menstrual health, bone health and energy availability) (Mountjoy et al., 2014). It is now known that RED-S can impact many other physiological functions of the body including metabolic rate, immunity, protein synthesis, cardiovascular and physiological health (Mountjoy et al., 2014). Increased clinical observations also showed that LEA can affect male athletes (Mountjoy et al., 2014). Athletes living with RED-S also experience many consequences to their training and performance levels (Ackerman et al., 2019). Athletes with RED-S exhibit a decrease in their physiological response to training, as well as impaired judgment, decreased coordination, concentration, and endurance, increased irritability, and depression (Figure 1) (Ackerman et al., 2019; Mountjoy et al., 2014). RED-S also increases the likelihood of bone stress injuries (BSI) including stress fractures (Rizzone et al., 2017). In a 2014 study, Barrack and colleagues found that in female distance runners, the presence of one symptom of RED-S increased the incidence rate of a BSI from 15% to 21%, while the presence of two symptoms increased the incidence of BSI to 30%. Lastly, in women with three or more symptoms, the incidence rose to 50% (Barrack et al., 2014).

Chronic LEA can lead to long term health consequences such as osteoporosis due to chronic low bone mineral density and impairment of the Hypothalamic-Pituitary Ovarian
(HPO) Axis (Boutari et al., 2020). Impairments of the HPO axis can lead to infertility, and other reproductive issues in both men and women (Boutari et al., 2020). The body adapts to chronic LEA by redirecting the energy needed for intense training from other physiological functions causing impairments to metabolic rate, and in adolescents, can cause lack of onset of puberty, menstrual abnormalities, and stunted growth (Hamer et al., 2023; Simič et al., 2022). Additionally, short term LEA can increase markers of bone reabsorption and decrease markers of bone formation (Papageorgiou et al., 2018). Individuals with LEA can present with lower bone mass, altered bone metabolism, and decreased bone strength, therefore increasing the risk of BSI’s both short and long term (Papageorgiou et al., 2018).

In 2022, Gillbanks, Mountjoy and Filbay investigated former lightweight rowers’ perspectives living with RED-S in the United Kingdom (UK). Participants reported several psychosocial implications such as decreased social interaction, difficulty maintaining relationships, low mood and emotional regulation, poor concentration, an overall negative body image, and guilt and anxiety around food (plus disordered eating). Physical implications included disturbed sleep, decreased recovery and performance, gastrointestinal issues, menstrual dysfunction, pain, injury, and weakened immune systems. Participants also reported that some of the implications from RED-S persisted after retirement from sport. The findings from this study help to highlight the importance of effective prevention and management programs for athletes, especially those in sports where the prevalence of RED-S may be higher (Gillbanks et al., 2022). However, it is also important to increase awareness of RED-S for athletes in sports that may not traditionally be at higher risk of RED-S as the amount of research about RED-S in these sports may be
limited (O’Donnell et al., 2023). Most studies about RED-S are conducted on sports that place emphasis on aesthetics, endurance, or weight-restriction, however, RED-S can exist in strength-based sports as well, such as hockey, netball and soccer (O’Donnell et al., 2023).

Identification/Diagnosis of RED-S

Although the IOC consensus statement on RED-S was first published in 2014 and updated in 2018, RED-S remains underdiagnosed and poorly recognized by health professionals, coaches, and athletes (Curry et al., 2015; Miller et al., 2012). Recent studies estimate the prevalence of RED-S across various sports to be from 22-58% with some studies showing that as high as 70-80% of elite athletes exhibit one or more symptom of RED-S (Gillbanks et al., 2022; Lodge et al., 2022; Rogers et al., 2021; VanBaak & Olson, 2016). The prevalence of RED-S is highest in athletes participating in weight-class sports or sports where a lower body weight is often desired such as dance, wrestling, lightweight rowing, and ballet (Jagim et al., 2022). It is also high in endurance sports, ultra-distance sports, and sports that require a high volume of training as it can be hard for these athletes to consume an adequate number of calories to offset the energy that they expend during training (Jagim et al., 2022). RED-S is also common in sports where subjective judging takes place, for example, in synchronized swimming, gymnastics and figure skating (Jagim et al., 2022).

Management of RED-S

Although there is a high prevalence of RED-S among elite athletes, many athletes do not receive appropriate education about RED-S nor proper management after being
diagnosed (Lodge et al., 2022). An adequate knowledge of RED-S is important for PTs and other health care professionals (HCPs) who work with athletes due to the severity of the health and performance consequences that the condition can have if left untreated (Curry et al., 2015; Gillbanks et al., 2022). If undiagnosed or managed incorrectly, RED-S can negatively impact an athlete’s performance due to increased rates of injury leading to prolonged time away from training, longer recovery times, reductions in physical, psychological, and mental capacity and impairments in muscle mass and function (Curry et al., 2015, Fogelholm, 1994). Early detection of RED-S and educating athletes who engage in sports that put them at a higher risk for RED-S is critical to preventing the long-term health consequences of the condition (De Souza et al., 2014; Mountjoy et al., 2014; Nattiv et al., 2007).

**RED-S and Physiotherapy**

Recent surveys report that fewer than 50% of physicians, coaches, PTs, and athletic therapists (ATs) could correctly identify the three components of the Female Athlete Triad or the symptoms of RED-S (Mountjoy et al., 2018). The prevention of RED-S requires increased awareness among athletes as well as coaches, PTs, and other HCPs (Mountjoy et al., 2018). As key members of elite athletes and sports teams’ medical staff, PTs are directly responsible for injury prevention and treatment as well as rehabilitation following an injury (Bulley & Donaghy, 2005). PTs are often the first people to see athletes following an injury and play major roles in their recovery (Hausenblas et al., 2017). The overarching goal of physiotherapy is injury rehabilitation, and making the athletes’ return to play as short as possible while preventing future injury (Lee, 2011). At some levels of elite sport, PTs also screen athletes before the start of each season (‘The Role & Benefits of Sports
Physiotherapy,” 2021). Since athletes (particularly those in weight-restricted sports) are at a high risk of developing RED-S, it is important that PTs have an adequate knowledge of the condition (Torstveit et al., 2019).

Despite the important role that PTs play in the identification and management of RED-S, there has been little research done on PTs knowledge of the symptoms and physiological consequences of RED-S or their confidence levels in treating and managing the condition. In 2022, Gillbanks and colleagues attempted to investigate the knowledge and management of RED-S in 12 PTs in the UK who had worked with lightweight rowers through conducting interviews both with the PTs as well as with their athletes. Throughout the interviews, five key themes were identified. First, PTs were found to have an insufficient knowledge of RED-S: only 42% of interviewed PTs correctly identified the symptoms of RED-S, while the other 58% had no previous knowledge of RED-S before the interview, despite working closely with lightweight rowers, a population at high risk of the condition. There was also a common misconception among PTs that only women could be affected by the condition. The second theme that emerged in this study was that there was a lack of education available for PTs regarding RED-S. None of the PTs reported receiving any kind of formal education about RED-S while completing their degrees and training, and those who did know about RED-S reported that they had sought the information themselves through research articles or the internet. Third, PTs also reported feeling that they did not have the necessary skillsets to recognize RED-S in their athletes and stated that they did not feel comfortable managing the condition or helping educate their athletes about RED-S. Due to the PTs in this study’s lack of confidence managing RED-S, a fourth theme of commonly referring athletes to other HCPs to help them manage
RED-S emerged. Lastly, the theme of prioritizing performance over health was evident as PTs reported discomfort in speaking about the extreme weight loss aspect of RED-S with athletes and reported worry that having these discussions may cause tensions with coaches (Gillbanks et al., 2022).

Moreover, the athletes involved in this study expressed dissatisfaction with the lack of education about RED-S provided to them by their team PTs and other HCPs (Gillbanks et al., 2022). The athletes also reported wishing they had received more information about the potential long-term impacts of RED-S, which aligned with 67% of PTs involved in the study reporting that they believed their lack of knowledge of RED-S could result in long-term health implications for the athletes (Gillbanks et al., 2022). This is especially important as inappropriate management of RED-S can result in significant long-term health issues such as osteoporosis and other systemic illnesses (Boutari et al., 2020). For PTs working in sports where athletes are at a high risk of RED-S, it is important for them to understand the signs and symptoms as well as which HCPs to refer athletes to when needed to ensure the best management and treatment for the athletes (Gillbanks et al., 2022). The appropriate management of RED-S requires a multidisciplinary team of HCPs including PTs, doctors, registered dietitians, and coaches; therefore, it is essential that PTs know how to effectively communicate between the different members of their health care team to help best assist the athlete (Gillbanks et al., 2022).
Chapter II: Identifying and managing RED-S: What is the physiotherapist experience? A cross-sectional survey of Canadian physiotherapists

Introduction

Relative Energy Deficiency in Sport (RED-S) is a condition recognized and supported by the International Olympic Committee (IOC) that is characterized by prolonged low energy availability (LEA) and can affect and athletes’ optimal bodily functions and performance in sport (Figure 1) (Gillbanks et al., 2022; Mountjoy et al., 2018, Mountjoy et al., 2014). Recent studies have estimated the prevalence of RED-S across various sports to range from 22-58% with some studies showing that as high as 70-80% of elite athletes exhibit one or more symptoms of RED-S (Gillbanks et al., 2022; Lodge et al., 2022; Rogers et al., 2021; VanBaak & Olson, 2016). The prevalence of RED-S is highest in athletes participating in weight-class sports or sports where a lower body weight is often desired such as dance, wrestling, lightweight rowing, and ballet (Jagim et al., 2022). It is also high in endurance sports, ultra-distance sports and sports that require a high volume of training such as running and swimming as it can be hard for these athletes to consume an adequate number of calories to offset the energy, they expend during training (Jagim et al., 2022). RED-S is also prevalent in sports where subjective judging takes place; for example, in synchronized swimming, gymnastics and figure skating (Jagim et al., 2022) RED-S also increases the likelihood of bone stress injuries (BSI) including stress fractures (Rizzone et al., 2017).

Early detection of RED-S and educating athletes who engage in sports that put them at a higher risk for RED-S is critical to preventing long-term health consequences (De
Souza et al., 2014; Mountjoy et al., 2014; Nattiv et al., 2007). An adequate knowledge of RED-S is important for PTs and other health care professionals (HCPs) who work with athletes due to the severity of the short- and long-term health consequences if left untreated (Curry et al., 2015; Gillbanks et al., 2022). Although there is a high prevalence of RED-S among elite athletes, many athletes do not receive appropriate education about RED-S or proper management after being diagnosed (Lodge et al., 2022). Currently, it is unclear what training exists in Canada for PTs regarding the diagnosis and treatment of RED-S, or if PTs feel confident in their ability to assist an athlete with managing RED-S.

Therefore, our study investigated Canadian PTs knowledge, confidence levels, exposure, and educational experience identifying and managing RED-S throughout their practice. Specifically, we investigated where PTs learned about RED-S, their exposure to RED-S in their practice and their current knowledge of and confidence levels in recognizing, managing, and treating RED-S. By furthering our understanding of Canadian PTs knowledge, confidence, and current practices, regarding RED-S, we can identify any gaps in areas where improvements in training for PTs may be necessary to lower the prevalence of RED-S, inform clinical practice, improve the overall health of athletes, and increase longevity in sport.

Methods

Ethics Approval

The study protocol and consent form were approved by the University of Western Ontario’s Health Sciences Research Ethics Board (HSREB ID# 121332) and conformed to
the standards set by the *Declaration of Helsinki*. All participants provided electronic informed consent prior to beginning the survey.

**Study Design**

Using a cross-sectional study design, an anonymized online self-reported questionnaire was designed to examine Canadian PTs knowledge, confidence levels, clinical exposure, and educational experience recognizing the signs and symptoms of RED-S as well as in helping athletes manage the condition. The survey was adapted from a 2022 survey designed by Lodge and colleagues. PTs were also asked to report where they received their training on managing the condition. The online survey was delivered via Qualtrics and was available for four months from December 2022 to March 2023 via a provided link (Qualtrics, Provo, Utah).

**Participants**

Participants were registered PTs actively practicing in Canada. We invited PTs to participate in the study by reaching out to the national division of the Canadian Physiotherapy Association (CPA) as well as its associated divisions: the Women’s Health Division (WHD), Sport Physiotherapy Canada (SPC), the Orthopedic Division (CPA Orthodiv), the Pain Science Division (PSD), the Cardiorespiratory Division (CRD), the Private Practice Division (CPA Private), and the Clinical Education Network. The administrative staff in each division distributed an advertisement or poster featuring a link to an anonymized online self-reported questionnaire in their monthly newsletter and on their social media accounts. The advertisement was also shared on the social media accounts of the study team members to enhance recruitment.
Inclusion and Exclusion Criteria

To be included, participants were required to be registered PTs in Canada defined as: those who had passed the written component of the Physiotherapy Competency Examination (PCE) administered by the CPA, who are registered with their provincial/territorial board, and are actively practicing in Canada under the title of physiotherapist or physiotherapist resident. Additionally, participants needed to be over 18 years of age, have the ability to communicate in (read/write) and understand English and have access to an electronic device (tablet, mobile device, laptop, or desktop computer). Those not actively practicing (retired PTs and those working purely in research, administration, or academic positions), those practicing outside of Canada, or registered outside of Canada, PT students, those not able to communicate in and understand English, and those without access to a laptop or desktop computer were excluded.

Survey Development

The survey used a mixed-methods approach to assess Canadian PTs knowledge and understanding of RED-S, as well as their confidence levels in treating and managing the condition. We also investigated different participant characteristics, as well as their ability to diagnose, and manage RED-S. PTs were also asked questions surrounding their educational and clinical experiences with RED-S.

Knowledge-based questions were adapted from a pre-existing questionnaire used by Lodge and colleagues (2022). The survey by Lodge and colleagues (2022) was tested for content validity as it was reviewed and edited by three content experts. The survey was then tested for reliability among NCAA collegiate athletes and coaches. Although the
previous survey was tested for reliability, it featured many questions about the Female Athlete Triad, and lacked questions about the management of RED-S, therefore our study was adapted to include more questions about RED-S. The survey by Lodge and colleagues., (2022) was also adapted from a previous survey designed to measure knowledge about the Female Athlete Triad among collegiate coaches (Frideres et al., 2015; Lodge et al., 2022). Our survey was adapted to better match the goals of our study, therefore, questions focusing specifically on the Female Athlete Triad as opposed to RED-S were eliminated. Our survey was expanded to include more questions surrounding the management and treatment of RED-S, the clinical experience of Canadian PTs, and additional qualitative elements to enrich the quantitative information.

Scoring

PTs were asked a series of 15 knowledge-based questions centered around the symptoms, management, and physiology behind RED-S (see supplemental Appendix C). Before beginning the survey, participants were asked to answer each question based off their existing knowledge of the condition and to avoid looking up any information about RED-S while completing the survey. Each participant was assigned a correctness score that was determined by the technique used by Lodge and colleagues (2022). Participants received one point for each correct response on questions 10a-13a, and 17a-25a. On questions 14a, 15a, and 16a (select all that apply), +0.5 was given for each correct response, and -0.5 was taken away for each incorrect response to offset those who had selected every answer. The highest possible scores on questions 14a, 15a, and 16a were 6, 8, and 6 respectively. The highest possible score on the survey was 35.
Following each knowledge-based question, PTs were asked to report their confidence in their answers (Question 10b-25b) on a 5-point Likert scale. The total confidence score for each participant was summed out of 64. Participants answered the question “How confident are you in your answer?” on a 5-point Likert scale and received 0-4 points on each of the 15 confidence-related questions (Table 1).

Table 1: Template of the scoring method used to analyze the confidence-related questions. Adapted from Lodge et al., 2022.

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Somewhat confident</th>
<th>Fairly confident</th>
<th>Completely confident</th>
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<tbody>
<tr>
<td>+0</td>
<td>+1</td>
<td>+2</td>
<td>+3</td>
<td>+4</td>
</tr>
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</table>

Statistical/Data Analysis

Participants were divided into one of five groups based on their self-reported specialty (Sports PT, Sports and Women’s Health PT, Orthopedic PT, Women’s Health PT, Other). Both the knowledge and confidence scores of each group were analyzed and compared by computing a one-way independent sample analysis of variance (ANOVA). Data regarding PTs exposure to RED-S as well as their educational experience with RED-S were presented using percentages as well as descriptive statistics using means and SD. Incomplete survey responses were excluded from data and statistical analysis. Data was analyzed using Excel, and Rstudio (Version 1.4.1717). The level of significance was set at p≤0.05.
Results

*Participant characteristics*

Participant data was presented as means ± standard deviation (SD). Eighty-six participants consented to begin the study. Participants were divided into one of five groups based on their self-reported specialty (Sports PT, Sports and Women’s Health PT, Orthopedic PT, Women’s Health PT, Other). If participants selected that they worked in more than one area, they were placed in the group most likely to encounter an athlete affected by RED-S. For example, if a PT selected that they worked in Orthopedic and Cardiovascular PT, they were placed in the Orthopedic group. One respondent was removed due to stating that they were retired. Seventeen participants were removed from data analysis due to completing less than 10% of the survey (Langkamp et al., 2010). Therefore, a total of 69 participants were included in the data analysis. Participant characteristics and main specialty are shown in Table 2.
Table 2: Physiotherapist Demographics.

<table>
<thead>
<tr>
<th>Age (n, %)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>18-24</td>
<td>3 (4.5%)</td>
</tr>
<tr>
<td>25-29</td>
<td>8 (12.1%)</td>
</tr>
<tr>
<td>30-34</td>
<td>17 (25.8%)</td>
</tr>
<tr>
<td>30-35</td>
<td>5 (7.6%)</td>
</tr>
<tr>
<td>40 and over</td>
<td>33 (50.0%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender (n, %)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Man</td>
<td>12 (17.7%)</td>
</tr>
<tr>
<td>Woman</td>
<td>54 (79.4%)</td>
</tr>
<tr>
<td>Prefer not to say</td>
<td>2 (2.9%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Racial or Cultural Group (n, %)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>60 (84.5%)</td>
</tr>
<tr>
<td>South Asian (e.g., East Indian, Pakistani, Sri Lankan)</td>
<td>3 (4.2%)</td>
</tr>
<tr>
<td>Chinese</td>
<td>1 (1.4%)</td>
</tr>
<tr>
<td>Black</td>
<td>1 (1.4%)</td>
</tr>
<tr>
<td>Arab</td>
<td>1 (1.4%)</td>
</tr>
<tr>
<td>Southeast Asian (e.g., Vietnamese, Cambodian, Malaysian, Laotian)</td>
<td>0 (0.0%)</td>
</tr>
<tr>
<td>Japanese</td>
<td>1 (1.4%)</td>
</tr>
<tr>
<td>Other</td>
<td>2 (2.8%)</td>
</tr>
<tr>
<td>Prefer not to say</td>
<td>2 (2.8%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How many years of experience of you have working as a licensed physiotherapist?</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 year</td>
<td>6 (9.0%)</td>
</tr>
<tr>
<td>1-2 years</td>
<td>5 (7.5%)</td>
</tr>
<tr>
<td>3-5 years</td>
<td>5 (7.5%)</td>
</tr>
<tr>
<td>6-10 years</td>
<td>19 (28.4%)</td>
</tr>
<tr>
<td>1-20 years</td>
<td>10 (15.0%)</td>
</tr>
<tr>
<td>20+ years</td>
<td>22 (32.8%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Speciality</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sports PT</td>
<td>23 (33.8%)</td>
</tr>
<tr>
<td>Sports and WH</td>
<td>5 (7.4%)</td>
</tr>
<tr>
<td>Orthopaedics</td>
<td>27 (39.7%)</td>
</tr>
<tr>
<td>Women’s Health</td>
<td>5 (7.4%)</td>
</tr>
<tr>
<td>Other</td>
<td>8 (11.8%)</td>
</tr>
</tbody>
</table>

Knowledge and Confidence Regarding RED-S (Q10a-25b)

Participants’ cumulative average scores on each question in the knowledge section of the survey are displayed in Table 3. There were no significant differences between the results of each group in terms of knowledge scores (mean + SD, [95% CI]); Sports PT: 25.6 ± 2.7, (24.5-26.7); Sports and Women’s Health PT: 26.3 ± 1.4, (25.1-27.5);
Orthopedics: 24.8 ± 4.0, (23.3-26.3); Women’s Health: 25.7±3.9, (22.3-29.1); Other: 22.1 ±7.8, (16.7-27.5) (p=0.375), or confidence scores; Sports PT: 42.3 ± 9.3, (28.5-46.1); Sports and Women’s Health PT: 49.4± 4.9, (45.1-53.7); Orthopedics: 46.8 ± 11.0, (31.1-42.1); Women’s Health 36.6 ± 14.5, (37.2-56.4); Other: 33.6 ±15.9, (22.6-44.6); (p=0.0762) (Table 4).
Table 3: Overall Knowledge-Based Correctness Scores Among Canadian PTs.

<table>
<thead>
<tr>
<th>Knowledge-Based Question</th>
<th>Correct Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q10a: What is the underlying cause of RED-S?</td>
<td>63.2%</td>
</tr>
<tr>
<td>Q11a: The Female Athlete Triad is Made up of Three Components, list as many as you can below</td>
<td>65.0%</td>
</tr>
<tr>
<td>Q12a: Who can be affected by RED-S?</td>
<td>72.1%</td>
</tr>
<tr>
<td>Q13a: RED-S can occur:</td>
<td>80.9%</td>
</tr>
<tr>
<td>Q14a: Select all possible health consequences of RED-S from the list below (select all that apply)</td>
<td>65.1%</td>
</tr>
<tr>
<td>Q15a: Select all possible performance consequences of RED-S from the list below</td>
<td>80.3%</td>
</tr>
<tr>
<td>Q16a: Select all possible signs and symptoms of RED-S from the list below (select all that apply)</td>
<td>60.0%</td>
</tr>
<tr>
<td>Q17a: The health and performance consequences of RED-S can affect an individual:</td>
<td>95.6%</td>
</tr>
<tr>
<td>Q18a: Menstrual Irregularity is a normal consequence of high-level training</td>
<td>86.8%</td>
</tr>
<tr>
<td>Q19a: There are no consequences associated with a female athlete losing their period</td>
<td>94.1%</td>
</tr>
<tr>
<td>Q20a: Repeated Stress Fractures should serve as a warning sign of low bone mineral density:</td>
<td>97.1%</td>
</tr>
<tr>
<td>Q21a: Adolescent and collegiate-aged athletes who suffer from bone mineral loss density can generally recuperate all bone loss later in life:</td>
<td>58.8%</td>
</tr>
<tr>
<td>Q22a: The loss of how many consecutive menstrual cycles is considered Amenorrhea?</td>
<td>47.1%</td>
</tr>
<tr>
<td>Q23a: In order for RED-S to be diagnosed, all symptoms of RED-S should be present (True/False)</td>
<td>70.6%</td>
</tr>
<tr>
<td>Q24a: Once an athlete has a confirmed symptom of RED-S, it is important to screen for other symptoms and health consequences of RED-S (True/False)</td>
<td>86.8%</td>
</tr>
<tr>
<td>Q25a: An efficient way to screen for RED-S includes using the LEAF-Q*, mental health screening questionnaires, nutritional screening questionnaires and a history of bone stress injuries: (True/False)</td>
<td>56.7%</td>
</tr>
</tbody>
</table>

*LEAF-Q; Low Energy Availability in Females Questionnaire
Table 4: Knowledge and confidence scores between groups.

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Number of participants</th>
<th>Knowledge Score (95% CI)</th>
<th>%</th>
<th>Confidence Score (95% CI)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sports PT</td>
<td>23</td>
<td>25.6 ± 2.7 (24.5-26.7)</td>
<td>73.2%</td>
<td>42.3 ± 9.3 (28.5-46.1)</td>
<td>66.2%</td>
</tr>
<tr>
<td>Sports and WH</td>
<td>5</td>
<td>26.3 ± 1.4 (25.1-27.5)</td>
<td>75.1%</td>
<td>49.4 ± 4.9 (45.1-53.7)</td>
<td>77.2%</td>
</tr>
<tr>
<td>Orthopaedics</td>
<td>27</td>
<td>24.8 ± 4.0 (23.3-26.3)</td>
<td>70.9%</td>
<td>36.6 ± 14.5 (31.1-42.1)</td>
<td>57.2%</td>
</tr>
<tr>
<td>Women's Health</td>
<td>5</td>
<td>25.7 ± 3.9 (22.3-29.1)</td>
<td>73.4%</td>
<td>46.8 ± 11.0 (37.2-56.4)</td>
<td>73.1%</td>
</tr>
<tr>
<td>Other</td>
<td>8</td>
<td>22.1 ± 7.8 (28.5-46.1)</td>
<td>64.1%</td>
<td>33.6 ± 15.9 (22.6-44.6)</td>
<td>52.5%</td>
</tr>
</tbody>
</table>

Confidence

Twenty-seven percent (n=18) of Canadian PTs strongly agreed that they had sufficient knowledge to recognize the signs and symptoms of RED-S in an athlete while 12.3% (n=8) reported feeling completely confident in their ability to help an athlete manage RED-S. 50.0% (n=33) of PTs strongly agreed that they felt confident in their ability to refer an athlete to other healthcare professionals when necessary and work with them to help the athlete manage RED-S. 18.0% (n=11) of PTs reported feeling confident in their ability to design a treatment plan for an athlete with RED-S. PTs self-reported confidence levels for each question are included in Figure 2. For a full list of survey questions, see supplemental Appendix C.
Figure 2: PTs self-reported confidence levels following the knowledge-related questions.

Exposure

In their professional role, 67.7% (n=46) of PTs reported that they were familiar with RED-S, while 25.0% (n=17) reported that they were unfamiliar with RED-S (7.3% [n=5] reported that they were “unsure”). 44.8% (n=30) of PTs reported that they had treated a patient with RED-S and/or played a role in helping them manage the condition. When PTs were asked how familiar they were with RED-S, only 9.0% (n=6) reported that they were extremely familiar with RED-S. 25.3% reported that they were somewhat familiar with RED-S, 31.0% reported mild familiarity with RED-S, 22.4% reported slight familiarity with RED-S, and 11.9% reported that they were not at all familiar with RED-S.
When asked where PTs with knowledge of RED-S first learned about the condition, 39.5% reported learning about RED-S from personal experience or self-study (Table 5). An additional 9.3% of PTs reported first learning about RED-S during their clinical practice. PTs were then asked a series of questions regarding their educational experiences and opinions (Table 6). PTs were also asked what kind of resources they feel they would benefit from regarding generating awareness about RED-S among athletes and coaches. PTs expressed a need for educational resources that concisely sum up the best practice measures regarding the signs, symptoms, and management protocol for RED-S. Webinars, online courses and videos were suggested to help inform those who had previously graduated from PT school. The integration of RED-S into the PT school curriculum was also suggested. PTs also expressed a desire for shareable resources written in lay language (i.e., pamphlets, infographics) that could be distributed to patients and coaches to further increase their knowledge of RED-S as well. A need for specific, universal diagnostic tools, and management protocols was expressed.

Table 5: PTs were asked to report where they first learned about RED-S. Participants responses were divided up into the categories below and reported as percentages.

<table>
<thead>
<tr>
<th>Education</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>During their Undergraduate Degree</td>
<td>9.3%</td>
</tr>
<tr>
<td>During Physiotherapy school</td>
<td>4.7%</td>
</tr>
<tr>
<td>School (unspecified)</td>
<td>18.6%</td>
</tr>
<tr>
<td>While pursuing a post-grad specialization (e.g., Sport PT)</td>
<td>16.2%</td>
</tr>
<tr>
<td>While studying for Physiotherapy Licencing Exams</td>
<td>2.3%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Through personal experience or self-study</td>
<td>39.5%</td>
</tr>
<tr>
<td>Through Clinical Practice</td>
<td>9.3%</td>
</tr>
</tbody>
</table>
Table 6: PTs Self-Reported Educational Experience and Opinions about RED-S.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Somewhat Disagree</th>
<th>Neither agree nor disagree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of RED-S is a necessary component of my clinical physiotherapy practice</td>
<td>3.3%</td>
<td>6.1%</td>
<td>15.2%</td>
<td>25.8%</td>
<td>50.0%</td>
</tr>
<tr>
<td>Physiotherapists would benefit from more training concerning RED-S.</td>
<td>0%</td>
<td>0%</td>
<td>3.0%</td>
<td>16.0%</td>
<td>48.0%</td>
</tr>
<tr>
<td>I feel I have sufficient knowledge to recognize the symptoms and red flags of RED-S in an athlete:</td>
<td>10.6%</td>
<td>5.2%</td>
<td>7.6%</td>
<td>39.4%</td>
<td>27.7%</td>
</tr>
<tr>
<td>I believe that lack of education is a potential barrier that could limit the management and care of an athlete living with RED-S.</td>
<td>0%</td>
<td>0%</td>
<td>4.5%</td>
<td>23.9%</td>
<td>71.6%</td>
</tr>
</tbody>
</table>
Chapter III: Discussion and Summary

Discussion

Using a cross-sectional survey, we examined Canadian PTs knowledge, confidence, exposure to and educational experiences regarding RED-S in their clinical practice. When PTs were divided into a total of five groups based on their self-reported specialty, there was no significant difference in the average knowledge and confidence scores between Sports PTs, Sports and Women’s Health PTs, Orthopedic PTs, Women’s Health PTs, and those practicing in other specialties. Although there was no significant difference between the knowledge and confidence scores between the different groups, Sport and Women’s Health PTs scored the highest on each respective section. Women’s Health PTs and Sports PTs scored similar in terms of knowledge; however, Sports PTs were less confident in their knowledge of RED-S than Women’s Health PTs despite likely working the most with athletes. As expected, those who were in the “other” group scored the lowest overall knowledge and confidence scores.

Canadian PTs scored an average of 71.7% on the knowledge section of the survey and an average of 51.1% on the confidence section of the survey. Canadian PTs knowledge scores were slightly lower than American ATs who took a similar survey by Lodge et al (2022) and scored an average of 77.5% on the knowledge section of their survey. Canadian PTs confidence scores were substantially less (51.1 %) than American ATs who scored an average of 79.5% on their confidence scores. When Gillbanks et al. (2022) surveyed UK PTs, only 42.0% could identify the characteristics of RED-S and 58.0% had knowledge of RED-S prior to the interview (Gillbanks et al., 2022). When compared to those in the UK,
67.6% (n=46) of Canadian PTs reported prior knowledge of RED-S and 60.0% of Canadian PTs were able to correctly identify the symptoms of RED-S (Gillbanks et al., 2022).

Overall, Canadian PTs scored similarly to UK PTs and American ATs in terms of RED-S related knowledge. American ATs may have scored slightly higher than both Canadian and UK PTs potentially due to ATs spending more time on the frontlines of sporting events. ATs may be directly exposed to athletes during practice and competitions more so than PTs who may tend to see athletes more commonly after an injury occurs and an athlete or coach retroactively seeks help. Our survey also included any practicing PT in Canada to gain an idea of RED-S-related knowledge among Canadian PTs, meaning that our results included PTs with other specialties who may not tend to work with athletes as much as ATs. This may also account for Canadian PTs scoring lower than American ATs on both the knowledge and confidence-related sections of the respective surveys.

It is evident that Canadian PTs felt far less confident in their ability to diagnose and manage RED-S than American ATs. This lack of confidence could lead to improper management of the condition and increase the risk of long-term health consequences for the athlete. This lack of confidence could be due to a lack of exposure to RED-S throughout their educational and clinical careers. Only 67.6% of Canadian PTs reported that they were familiar with RED-S in their professional role. Due to various gaps in PTs knowledge of the condition, combined with potential under reporting of symptoms from athletes, the number of PTs who have interacted with RED-S in their practice could unknowingly be much higher. Increasing PTs knowledge of RED-S increases the likelihood that they will be able to recognize the red flags of the condition, which is often masked by various symptoms such as BSIs, disordered eating, and symptoms of overtraining.
The results from this study suggest that Canadian PTs feel that lack of education about RED-S is a barrier to the proper identification, treatment, and management of RED-S. 39.5% of Canadian PTs reported first learning about RED-S through personal experience and/or self-study, and 9.3% reported first learning about RED-S through clinical practice, meaning that roughly 50% of Canadian PTs reported learning about RED-S during their school curriculum. Results of this survey reflect Canadian PTs desire to bridge any existing gaps in their knowledge about RED-S if educational resources were made available to help with this endeavor. PTs conveyed a need for a concise summary of the key features of RED-S, including the signs and symptoms of the condition, as well as treatment, management and return to play strategies. Participants in the study expressed a desire for increased educational resources including short online courses, and webinars about the topic. They also expressed a need for tangible resources such as pamphlets and posters (including those writing in lay language) that could be distributed to athletes and coaches to increase their knowledge of the condition as well. Additionally, since those specializing in Sport PT work the most frequently with athletes, sports teams, and sports organizations, it is imperative that training for Sport PTs regarding RED-S be improved to help to mitigate the often-frequent underdiagnosis or misdiagnosis of RED-S (Curry et al., 2015, Fogelholm, 1994).

The underlying physiology of RED-S is complex, therefore, Canadian PTs stating that they would benefit from more up to date, concise, well-illustrated materials is consistent with the work done by Gillbanks and colleagues in 2022 where PTs in the UK also identified the lack of educational resources available regarding RED-S as a key reason for gaps in their knowledge of the condition. The results of this survey also aligned with
the findings of a 2020 narrative review by Louge and colleagues that investigated the literature available about the prevalence, risk, knowledge, and impact of RED-S on sports performance. Result of this review indicated that the development and implementation of programs to increase awareness and improve knowledge of RED-S and LEA for athletes was warranted in the United States (Logue et al., 2020), similar to how the results of our study highlighted the need for such resources in Canada.

Throughout the entirety of the survey, PTs confidence scores remained substantially lower than their knowledge scores. This shows that while PTs were for the most part able to answer the knowledge-based questions in this survey correctly, their self-reported confidence levels regarding the identification and management of RED-S were much lower. Additionally, only 60% of Canadian PTs correctly identified the signs and symptoms of RED-S. A poor knowledge of the signs and symptoms of RED-S on behalf of HCPs can lead to misdiagnosis, underdiagnosis and inappropriate management of the condition (Boutari, Panagiotis, et al., 2020). Since many athletes do not receive appropriate education about RED-S, it is important that HCPs have an adequate knowledge of RED-S, particularly those who work with athletes such as Sport PTs (Lodge et al., 2021, Gillbanks et al., 2022). Therefore, it is important for both the long- and short-term health of athletes that healthcare professionals including PTs have both the knowledge and the confidence to effectively diagnose, treat and manage RED-S.

Limitations

There are several limitations associated with cross-sectional surveys, as they address participants' feelings and experiences about a topic at a single point in time and
therefore do not show any temporal patterns in the data. Participants were also asked to answer questions about their PT school curriculum retrospectively which allows for potential recall bias to occur. The overall sample size for the study was limited, as were some of the sample sizes of specific specialties. The survey was also limited to PTs actively practicing in Canada. Limitations in sample size and geographical location can limit the overall generalizability of the results. There is also a potential risk of sampling bias in the case of this survey as PTs who were more interested in the topic of RED-S or had a better pre-existing knowledge of the condition may have been more likely to click on or fill out the survey.

Future Directions

As highlighted by the results of this study, there is a need for increased resources to be developed and made available about the most current best clinical practice guidelines regarding RED-S. PTs expressed a desire for resources such as webinars, short online courses, pamphlets, and infographics to be made available for not only their use, but that could also be distributed to athletes and coaches to raise awareness about the condition. It is also important to investigate the existing resources about RED-S and possible ways to distribute them to HCPs including PTs. Future research could be done that directly investigates the athletes experience with RED-S in their sport, as well as their experience managing the condition with the help of PTs. A needs assessment about living with RED-S from could be done from the athlete’s perspective to examine athletes competing at different levels satisfaction with the care they received during the treatment process.
Results from this assessment could then be further used to improve short- and long-term care athletes across various sports.

To further increase PT knowledge of RED-S, the condition could be incorporated into the Canadian physiotherapy school curriculum as well as into the Sport PT specialization requirements to aid in pre-professional development. Case studies that incorporate RED-S specific symptomology and management could be used to help PTs learn the diagnostic and treatment process. Specifically, clinical assessments incorporating RED-S should be added to the Sport PT specialization curriculum requirements.

RED-S could also be added to university and collegiate athletic department pre-participation screenings. If athletes are screened for the condition at the beginning of each season, it may help with early diagnosis of the condition as well as to increase the athlete’s awareness of RED-S and encourage them to seek help sooner if symptoms arise. If RED-S is more frequently talked about among athletic department screenings, it could help familiarize athletes with the signs and symptoms of the condition so that they may self-report symptoms earlier. Routinely screening athletes for RED-S would also help PTs who work with athletes remain familiar with the condition throughout their career. Additionally, the integration of the signs and symptoms of RED-S into pre-participation screenings could also help increase prevention strategies on behalf of athletes, coaches, and their team of health care professionals as topics such as nutrition and proper fueling can often become taboo topics not often spoken about. Frequently integrating the topic of RED-S and the importance of adequately fueling to avoid LEA can help to destigmatize the topics and bring important conversations about adequate nutrition and recovery to the forefront of maintaining athlete health.
Conclusion

This survey demonstrated gaps in Canadian PTs knowledge and confidence levels diagnosing, treating and managing RED-S. Canadian PTs expressed a need for more concise resources to be made available regarding the key features and best clinical practices managing RED-S. A poor knowledge of the signs and symptoms of RED-S on behalf of healthcare professionals can lead to misdiagnosis, underdiagnosis and inappropriate management of the condition, therefore, increasing awareness of RED-S in Canadian PTs is important to improve long-term athlete health and increase preventative strategies.
References


Appendices

Appendix A: Ethical Approval

Date: 2 November 2022
To:
Project ID: 121332
Review Reference: 2022-121332-72382

Study Title: Identifying and managing RED-S: What is the physiotherapist experience? A cross-sectional survey of Canadian physiotherapists
Application Type: HSREB Initial Application
Review Type: Delegated
Meeting Date / Full Board Reporting Date: 22 Nov 2022
Date Approval Issued: 02 Nov 2022 16:50
REB Approval Expiry Date: 02 Nov 2023

Dear [Name],

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the above mentioned study as described in the WREM application form, as of the HSREB Initial Approval Date noted above. This research study is to be conducted by the investigator noted above. All other required institutional approvals and mandated training must also be obtained prior to the conduct of the study.

Documents Approved:

<table>
<thead>
<tr>
<th>Document Name</th>
<th>Document Type</th>
<th>Document Date</th>
<th>Document Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>RED-S advertisement September 27</td>
<td>Recruitment Materials</td>
<td>27/Sep/2022</td>
<td>1</td>
</tr>
<tr>
<td>Email Scripts October 23</td>
<td>Email Script</td>
<td>23/Oct/2022</td>
<td>2</td>
</tr>
<tr>
<td>LOI October 23, 2022</td>
<td>Written Consent/Assent</td>
<td>23/Oct/2022</td>
<td>2</td>
</tr>
<tr>
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<td>Online Survey</td>
<td>23/Oct/2022</td>
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</tr>
<tr>
<td>RED-S Protocol October 23 (2)</td>
<td>Protocol</td>
<td>23/Oct/2022</td>
<td>2</td>
</tr>
</tbody>
</table>

Documents Acknowledged:

<table>
<thead>
<tr>
<th>Document Name</th>
<th>Document Type</th>
<th>Document Date</th>
<th>Document Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protocol References (1)</td>
<td>References</td>
<td>27/Sep/2022</td>
<td>1</td>
</tr>
</tbody>
</table>

No deviations from, or changes to, the protocol or WREM application should be initiated without prior written approval of an appropriate amendment from Western HSREB, except when necessary to eliminate immediate hazards to study participants or when the change(s) involves only administrative or logistical aspects of the trial.

REB members involved in the research project do not participate in the review, discussion or decision.

[Redacted]

Please do not hesitate to contact us if you have any questions.

Electrolyte signed:

[Signature]
Appendix B: Letter of Information

LETTER OF INFORMATION AND CONSENT FORM

Project Title: Identifying and managing RED-S: What is the physiotherapist experience? A cross-sectional survey of Canadian Physiotherapists

Principal Investigator: [Redacted]

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Co-Investigators: [Redacted]

Introduction and Study Background

You are reading this information because you are a licensed physiotherapist or physiotherapy resident practicing in Canada and have indicated interest in participating in an online research study about the Canadian Physiotherapists experience identifying and managing Relative Energy Deficiency in Sports (RED-S) (originally known “The Female Athlete Triad”).

Currently, a gap exists in what we know about the Canadian physiotherapists experience with identifying and managing RED-S throughout their practice. This study will investigate the knowledge physiotherapists have about RED-S and where they received any training or education on the subject. Results from this study will be used to highlight any potential areas where improvements in training for physiotherapists can be made in an attempt to lower the prevalence of RED-S improve the overall health of athletes and increase longevity in sport.

Participating in this study involves the completion of an online questionnaire. This letter contains information to help you decide whether to participate in this research study. It is important for you to understand why the study is being conducted and what it will involve. Please take the time to read this over carefully and feel free to contact a member of the study team to ask questions if anything is unclear.

Who can participate?

You are invited to participate if you are a registered physiotherapist or physiotherapy resident in Canada who is licensed to practice by your provincial/territorial regulatory college in addition to completing the written components Physiotherapy Competence Examination (PCE), are 18 years of age or older, are able to communicate (read/write) in and understand English and have access to any electronic device (tablet, mobile device, laptop, or desktop computer). Individuals who have retired from practice will be excluded from the study. The research team will recruit 150 individuals to participate in the study.

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How can I participate?

If you meet the eligibility criteria above, you can consent to participate in an online study which aims to discover Canadian physiotherapists’ exposure to RED-S in their practice, their current knowledge of RED-S, their confidence in recognizing, managing, and treating RED-S. The study also aims to investigate where physiotherapists received their education about RED-S. The online questionnaire takes about 10 minutes to complete. To access the survey, you can click “I consent to begin the study” at the end of the Letter of Information.

What are the potential benefits?

Participants may not experience any direct benefit from participation. However, as a crucial part of an athlete’s health care team it is important that physiotherapists have an accurate knowledge of the signs, symptoms, and management of RED-S. Therefore, this research is relevant to addressing the high prevalence of RED-S. Early detection and proper management of RED-S are essential to the recovery of the athlete and their long-term health. With the results of this study, we plan to increase awareness of the role that physiotherapists can play in helping an athlete recognize and manage RED-S. The results will also contribute to a growing area of research about injury prevention and promoting the long-term health of elite athletes with the goal of increasing longevity in their sport.

What are the risks to participating?

There is always a potential risk of data breach with any survey conducted online. We plan to uphold research integrity to the highest standard to prevent this from occurring. You will not be asked to identify yourself on the survey at any point. All data from the survey data will be stored on a secure Western University network server, which is only accessible by members of the research team. Study data will be downloaded and stored on our secure Western University network server at the end of the study and will be retained for 7 years as per UWO policy.

How will we keep your information safe during and after the study?

Access to the online survey will be granted using an anonymized link. No further identifying information will be collected during the study. Data from the study will be password-protected and stored on encrypted servers. When communicating study results in publications or presentations, only aggregate data will be presented, and no identifying information will be mentioned. Our study was reviewed by the Health Sciences Research Ethics Board (REB) at Western University. The REB has access to study information for monitoring, legal, and/or regulatory purposes only.

Can I withdraw from the study?

Participation in this study is voluntary. You may refuse to answer any survey question if you do not feel comfortable doing so. Your decision of whether to participate will not impact your current or future practice. Participants are allowed to withdraw from the study at any time. If you exit the questionnaire before clicking “submit” on the final page, no data will be collected. After
submission of the survey, should you decide, you would like to remove your data, you can contact the study researchers to locate your data (based off time of submission, age range and/or other answers) to remove your entire submission.

**What are the alternatives to being in the study?**

An alternative to the procedures described above is to not participate in the study and continue with your practice as you were before.

**What are the costs and or reimbursement involved in the study?**

There are no costs or reimbursements for participants to partake in the study.

**Who can I contact about the study?**

If you have any questions or concerns that may be raised by participating in the study, please contact

**Consent**

If you choose to participate, consent will be implied upon clicking continue and starting the survey.

Thank you.

Sincerely,
Appendix C: RED-S Survey

RED-S

By clicking the button below, you acknowledge: Your participation in the study is voluntary. You are 18 years of age or older. You are aware that you may choose to terminate your participation at any time for any reason.

- I consent to begin the study (1)
- I do not consent. I do not wish to participate (2)

Our team is curious about your existing knowledge of RED-S and would encourage you to answer the questions in the survey without the use of any external resources.

Q2 Are you currently a registered physiotherapist actively practicing in 2022 in Canada?
- Yes (1)
- No (2)

Display This Question:

If Are you currently a registered physiotherapist actively practicing in 2022 in Canada? = Yes

Q3 How many years of experience do you have working as a licensed physiotherapist?
- <1 year (1)
- 1-2 years (2)
- 3-5 years (3)
- 6-10 years (4)
- 11-20 years (5)
- 20+ years (6)

Q4 In what age group do you belong?
- 18-24 (1)
- 25-29 (2)
- 30-34 (3)
- 35-39 (4)
- 40 and over (5)

Q5 What is your gender?
- Man (1)
- Women (2)
- Non-binary / third gender (3)
- Prefer not to say (4)
- Self-identify (5)

Q6 What best describes the racial or cultural group(s) to which you belong? (Please select all that apply)
- White (1)
- South Asian (e.g. East Indian, Pakistani, Sri Lankan) (2)
- Chinese (3)
- Black (4)
- Filipino (5)
- Latin American (6)
- Arab (7)
- Southeast Asian (e.g. Vietnamese, Cambodian, Malaysian, Laotian) (8)
- West Asian (e.g. Iranian, Afghan) (9)
- Korean (10)
- Japanese (11)

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Q41 If you would like to provide additional feedback on the survey or your knowledge/experience working with RED-S, leave your comments below:

________________________________________________________________
- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Q34 I believe that lack of education is a potential barrier that could limit the management and care of an athlete living with RED-S.
- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Q35 I feel I have sufficient knowledge to recognize the symptoms and red flags of RED-S in an athlete:
- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Q36 I feel that I am confident in my ability to help an athlete manage RED-S.
- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Q37 I feel confident in my ability to refer an athlete to other health care professionals when necessary and work with them to help the athlete manage RED-S.
- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Q38 I feel confident in my ability to design a treatment rehabilitation plan for an athlete with RED-S.
- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Q39 Are you aware of any diagnostic and/or treatment plans for the effective management of RED-S?
- Yes (1)
- No (2)
- If yes, what tools are you referring to? (3)

Q40 What type of resources would you like to regarding RED-S to help spread awareness and education about the condition?
Q27 In your practice, how often would you say that you treat patients who have been diagnosed with RED-S?
- once per year (1)
- twice per year (2)
- more than three times per year (3)
- more than five times per year (4)
- monthly (5)

Q28 To your knowledge, have you ever treated a patient with suspected, or undiagnosed RED-S and/or played a role in helping them manage the condition
- Yes (1)
- No (4)
- Unsure (3)

Q29 In your practice, how often would you say that you treat patients with suspected or undiagnosed RED-S?
- once per year (1)
- twice per year (2)
- more than three times per year (3)
- more than five times per year (4)
- monthly (5)

Q30 How familiar are you with RED-S?
- I am not at all familiar (1)
- I am slightly familiar (2)
- I am somewhat familiar (3)
- I am moderately familiar (4)
- I am extremely familiar (5)

Q31 Where did you first learn about RED-S?

Q32 Knowledge of RED-S is a necessary component of my clinical physiotherapy practice
- Strongly agree (1)
- Somewhat agree (2)
- Neither agree nor disagree (3)
- Somewhat disagree (4)
- Strongly disagree (5)

Q33 Physiotherapists would benefit from more training concerning RED-S.
Q24a Once an athlete has a confirmed symptom of RED-S, it is important to screen for the other components and health consequences of RED-S.

- True (1)
- False (2)
- Unsure (3)

Q24b How confident are you in your answer?

- not at all confident (1)
- slightly confident (2)
- somewhat confident (3)
- fairly confident (4)
- completely confident (5)

Q25a An efficient way to screen for RED-S includes using the LEAF-Q, mental health screening questionnaires, nutritional screening questionnaires and a history of bone stress injuries:

- True (1)
- False (2)
- Unsure (3)

Q25b How confident are you in your answer?

- not at all confident (1)
- slightly confident (2)
- somewhat confident (3)
- fairly confident (4)
- completely confident (5)

Q26 To your knowledge, have you ever treated a patient who has been diagnosed with RED-S and/or played a role in helping them manage the condition?

- Yes (1)
- No (2)
Q19b How confident are you in your answer?
- not at all confident (1)
- slightly confident (2)
- somewhat confident (3)
- fairly confident (4)
- completely confident (5)

Q20a Repeated stress fractures should serve as a warning sign of low bone mineral density:
- True (1)
- False (2)
- Unsure (3)

Q20b How confident are you in your answer?
- not at all confident (1)
- slightly confident (2)
- somewhat confident (3)
- fairly confident (4)
- completely confident (5)

Q21a Adolescent and collegiate-aged athletes who suffer from bone mineral loss density can generally recuperate all bone loss later in life:
- True (1)
- False (2)
- Unsure (3)

Q21b How confident are you in your answer?
- not at all confident (1)
- slightly confident (2)
- somewhat confident (3)
- fairly confident (4)
- completely confident (5)

Q22a The loss of how many consecutive menstrual cycles is considered Amenorrhea?
- 1 (1)
- 2 (2)
- 3 (3)
- 4 or more (4)

Q22b How confident are you in your answer?
- not at all confident (1)
- slightly confident (2)
- somewhat confident (3)
- fairly confident (4)
- completely confident (5)

Q23a In order for RED-S to be diagnosed, all symptoms of RED-S should be present?
- True (1)
- False (2)
- Unsure (3)

Q23b How confident are you in your answer?
Q16a Select all possible signs and symptoms of RED-S from the list below (select all that apply):
- dizziness (1)
- stress fracture(s) (2)
- depression (3)
- hyperactivity (4)
- fatigue (5)
- low bone mineral density (6)
- mealtime anxiety (7)
- weight gain (8)
- irritability (9)
- amenorrhea (lack of menstruation) (10)
- sore throat (11)
- tachycardia (high resting heart rate) (12)
- abdominal pain (13)
- knuckle scars (14)
- dry hair & skin (15)
- Hypertension (16)

Q16b How confident are you in your answer?
- not at all confident (1)
- slightly confident (2)
- somewhat confident (3)
- fairly confident (4)
- completely confident (5)

Q17a The health and performance consequences of RED-S can affect an individual:
- Only while they are competing (1)
- Only while they are physically active (2)
- Over the course of the athlete’s lifetime (3)
- Only in adolescence (4)

Q17b How confident are you in your answer?
- not at all confident (1)
- slightly confident (2)
- somewhat confident (3)
- fairly confident (4)
- completely confident (5)

Q18a Menstrual irregularity is a normal consequence of high-level training.
- True (1)
- False (2)
- Unsure (3)

Q18b How confident are you in your answer?
- not at all confident (1)
- slightly confident (2)
- somewhat confident (3)
- fairly confident (4)
- completely confident (5)

Q19a There are no consequences associated with a female athlete losing their period
Q15a Select all possible performance consequences of RED-S from the list below (select all that apply):
  - Decreased endurance (1)
  - Infertility (2)
  - Increased risk of injury (3)
  - Improved performance in sports (4)
  - Insomnia (5)
  - Decreased muscle strength (6)
  - Increased muscle strength (7)
  - Decreased coordination (8)
  - Increased coordination (9)
  - Enhanced response to training (10)
  - Depression (12)
  - Irritability (13)
  - Decreased response to training (14)
  - Increased fine motor skills (15)
  - Decreased concentration (16)
  - Decreased glucose storage (17)

Q15b How confident are you in your answer?
  - not at all confident (1)
  - slightly confident (2)
  - somewhat confident (3)
  - fairly confident (4)
  - completely confident (5)
Who can be affected by RED-S?
- Only female athletes who have started to menstruate (1)
- Any physically active female (2)
- Only adolescent females (3)
- Any physically active male or female (4)

Q12b How confident are you in your answer?
- not at all confident (1)
- slightly confident (2)
- somewhat confident (3)
- fairly confident (4)
- completely confident (5)

Q13a RED-S can occur:
- Only in the presence of disordered eating (1)
- With or without disordered eating (2)
- Unsure (3)

Q13b How confident are you in your answer?
- not at all confident (1)
- slightly confident (2)
- somewhat confident (3)
- fairly confident (4)
- completely confident (5)

Q14a Select all possible health consequences of RED-S from the list below (select all that apply):
- Impaired menstrual function (1)
- Hematological health (2)
- Psychological health (3)
- Bone health (4)
- Immunological health (5)
- Growth and development (6)
- Endocrine health (7)
- Gastrointestinal health (8)
- Respiratory health (9)
- Metabolic health cardiovascular health (10)
- Vitamin and mineral health (11)
- Electrolyte imbalance (12)
- Blood sugar imbalance (13)
- Neurological health (14)
- Musculoskeletal health (15)
- Insomnia (16)

Q14b How confident are you in your answer?
Q7 What is your main area of practice?
- Pediatrics (1)
- Cardiorespiratory (2)
- Neurosciences (3)
- Senior health (4)
- Sports (5)
- Orthopedics (6)
- Oncology (7)
- Women’s health (8)
- Pain Science (9)
- Acupuncture (10)
- Global Health (11)
- Leadership (12)
- Private Practice (13)
- Other, please specify (14) ________________________________
- Prefer not to say (15)

Q8 What is your primary location of practice?
- hospital (3)
- outpatient private (4)
- outpatient publicly funded (5)
- academic institution (6)
- sports medicine clinic (7)
- other, please specify (8) ________________________________
- prefer not to say (9)

Q9 In your professional role, are you familiar with Relative Energy Deficiency in Sports (RED-S)?
- Yes (1)
- No (2)
- Unsure (3)

Q10a What is the underlying cause of RED-S?
- Period loss (amenorrhea) (1)
- Overtraining (2)
- low energy availability (3)
- osteoporosis (4)
- anemia (5)
- disordered eating (6)

Q10b How confident are you in your answer?
- not at all confident (1)
- slightly confident (2)
- somewhat confident (3)
- fairly confident (4)
- completely confident (5)

Q11a The Female Athlete Triad is made up of three components, list as many as you can below

Q11b How confident are you in your answer?
Curriculum Vitae

Laura J. Parkinson
School of Kinesiology, Faculty of Health Sciences
Western University
London, Ontario, Canada

Education
2021 – 2023 Master of Science (M.Sc.), Kinesiology (Integrative Biosciences), Western University, London, Ontario.
Honours: USPORTS Academic All Canadian 2021-2022, OUA all-Academic Team 2021-2022

2017 – 2021 Bachelor of Science in Health Science (B.Sc.), Sargent College of Health and Rehabilitation Boston University, Boston, Massachusetts.
Honours: Graduated Cum Laude, Member of the Sargent College Dean’s List (2017-2021), Member of the Patriot League Academic Honor Roll.

Work and Teaching Experience

Graduate Teaching Assistant
2023/01 – 2023/04 Kinesiology 2230B – Introduction to Exercise Physiology, Western University.


2022/09 – 2022/12 Kinesiology 2230A – Introduction to Exercise Physiology, Western University.

2022/01 – 2022/04 Kinesiology 2230B – Introduction to Exercise Physiology, Western University.

2021/09 – 2021/12 Kinesiology 2230A – Introduction to Exercise Physiology, Western University.

Research
Manuscripts Under Review (1)

Scholarships and Awards
Athletic Scholarships
2017 – 2021 Boston University Athletic Department, full athletic undergraduate scholarship, funded for 8 terms ($95 000 per year x 4).

Professional Development and Training


2023/07 Standard First Aid and CPR C, Canadian Red Cross.

2023/06 Basic Life Saving for Health Care Professionals, Canadian Red Cross.

2023/06 Phlebotomy Workshop, London Health Research.

2023/04 Good Clinical Practice (GCP)-Canada, Collaborative Institutional Training Initiative (CITI).

2023/04 Health Canada Division 5- Drugs for Clinical Trials Involving Human Subjects, Collaborative Institutional Training Initiative (CITI).

2023/04 The Biomedical Ethics Research Tutorial- Canada, Collaborative Institutional Training Initiative (CITI).

2022/02 WHMIS Training, Western University.


2021/09 Biosafety, Western University.

2021/09 Mental Health at Western, Western University.

2021/06 Accessibility for Ontarians with Disability Act (AODA) - Accessibility in Teaching, Western University.