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JCCA December 2024 Sports Chiropractic Special Issue: 16th Edition

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Assistant Editor

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KEY WORDS: sports, chiropractic

Éditorial
JCCA Décembre 2024 – Numéro spécial de la chiropratique sportive : 16e édition

MOTS CLÉS : sports, chiropratique

In recent years, the intersection of chiropractic care and sports medicine has garnered increasing attention. As we passed our 15-year milestone triumphantly, we celebrated the progress made by chiropractors in supporting athletes, preventing injuries, and optimizing performance, while also addressing emerging challenges and opportunities in the field.

This 16th issue of our sports-focused publication highlights elite athlete pregnancy complications, research priorities and investigative capacity in sports-focused chiropractic research, management of persistent patellofemoral pain conditions, and early cauda equina syndrome. In addition, for the first time we are publishing the abstracts of research poster presentations and a competition at the annual Royal College of Chiropractic Sports Sciences (Canada), RCCSS(C) Symposium held in early November 2024.

As you explore the diverse articles in this issue, we encourage you to reflect on the progress made and the path ahead. The dynamic and growing field of sports chiropractic offers unparalleled opportunities to make a meaningful impact on the health and performance of athletes everywhere. Let us continue to advance this work with dedication, innovation, and collaboration.

Thank you to our contributors, peer reviewers, the Canadian Chiropractic Association (CCA), the Royal College of Chiropractic Sports Sciences (Canada) (RCCSS(C)), and our readers for your commitment to excellence in sports chiropractic sports. Together, we are shaping the future of our profession and empowering athletes to achieve their best.

Sincerely,

Mohsen Kazemi, RN, DC, FRCCSS(C), FCCPOR(C), MSc, PhD

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A qualitative study investigating research priorities and investigative capacity in sports-focused chiropractic research, part 2: exploring the challenges and opportunities for research capacity development

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Objectives: *To explore the challenges and opportunities for research capacity development in the sports chiropractic field.*

Methods: *A qualitative description study was conducted using semi-structured interviews with 20 sports chiropractic researchers from eight countries and focus group interviews with 12 sports chiropractic leaders from Canada.*

Results: *Challenges and opportunities for research capacity development were identified within four main*

Une étude qualitative visant à examiner les priorités de recherche et la capacité de mener des enquêtes dans la recherche en chiropratique sportive, partie 2: exploration des défis et des opportunités pour le développement de la capacité de recherche.

Objectifs: *Explorer les défis et les opportunités pour le développement des capacités de recherche dans le domaine de la chiropratique sportive.*

Méthodes: *Une étude de description qualitative a été réalisée à l'aide d'entretiens semi-structurés avec 20 chercheurs en chiropratique sportive provenant de huit pays, ainsi que d'entretiens en groupe de discussion avec 12 chefs de file en chiropratique sportive du Canada.*

Résultats: *Des défis et des opportunités pour le développement des capacités de recherche ont*

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themes – 1) affiliations and collaborations, 2) human resources, 3) financial resources, and 4) operational resources. Profession-specific challenges included being "siloed", a lack of knowledge of the chiropractic profession, and its negative perception. Profession-specific opportunities included creating a sports chiropractic research chair/centre and engaging sports chiropractors in practice- and field-based research networks.

Conclusions: *These results can inform strategies to advance research capacity development for the sports chiropractic field and develop context-specific indicators for ongoing research capacity assessment.*

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KEY WORDS: Research Capacity, Sports, Chiropractic, Qualitative Research

été déterminés dans quatre thèmes principaux : 1) affiliations et collaborations, 2) ressources humaines, 3) ressources financières et 4) ressources opérationnelles. Les défis spécifiques à la profession comprenaient l'isolement, le manque de connaissance de la profession de chiropraticien et sa perception négative. Les opportunités spécifiques à la profession comprenaient la création d'une chaire ou d'un centre de recherche en chiropratique sportive et la mobilisation des chiropraticiens sportifs dans des réseaux de recherche en pratique et sur le terrain.

Conclusions: *Ces résultats peuvent éclairer les stratégies visant à promouvoir le développement des capacités de recherche dans le domaine de la chiropratique sportive et à élaborer des indicateurs spécifiques au contexte pour l'évaluation continue des capacités de recherche.*

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MOTS CLÉS : Capacité de recherche, sports, chiropratique, recherche qualitative

Introduction

Research in healthcare advances knowledge to support evidence-based care to improve patient outcomes.[1] With evidence indicating clinician engagement in research is associated with improvements in healthcare delivery[2,3], health professions play an important role as research partners in healthcare systems to benefit society. To meet this challenge, the Research and Education Committee of the Royal College of Chiropractic Sports Sciences (Canada) (RCCSS(C)) launched the "Advancing the Research Effort for Canadian Sports Chiropractors Initiative" to improve its ability to make meaningful research contributions.

Commencing in 2016, this initiative is an on-going research program with the aim of conducting a range of investigations to inform continuous strategy development to improve the research impact potential of the Canadian sports chiropractic field. The first investigation was an exploratory interview study to provide an initial understanding of the research needs and preferences of Canadian chiropractors practicing in sport.[4] These practitioners reported a preference for research to inform healthcare delivery within sport, such as conducting research on athletic injury, effects of interventions on athletic performance, and the care of athletes in clinical practice.[4] These findings suggested the Canadian sports chiropractic field could benefit from a specialty-specific research strategy to advance its research capabilities.

As a next step, a two-part qualitative study that interviewed sports chiropractic researchers and leaders was conducted. Part one[5] developed a list of research topics to inform a Delphi research prioritization study, and part two (reported in this manuscript) explored the investigative capacity of the sports chiropractic field. In part one, a total of 150 research priorities and six areas of research were identified.[5] These priorities were entered into the Delphi method, which is an iterative survey consensus process. The first Canadian[6] and International[7] Delphi research prioritization studies were published for the sports chiropractic field using expert panels of sports chiropractic academics, leaders, and clinicians. For the Canadian Delphi study[6], the top three research priorities were 1)

research on the effects of interventions on athletic outcomes, 2) research about sports healthcare teams, and 3) clinical research related to spinal manipulative and mobilization therapy. The three highest ranked conditions to research were low back pain, neck pain, and concussion. Collaborations with sports physicians and universities/colleges were rated as important research partnerships to pursue.[6]

While these two Delphi studies[6,7] established research priorities, it is uncertain if the sports chiropractic field has the capacity to conduct research in these identified areas. To determine the feasibility of conducting research on specific topics, it is important to understand a field's research capacity (defined as "the ability to engage in, perform or carry out quality research"[8]) and productivity (which is the research output of a field of study, such as publications, grants, conference presentations, etc.[9]). To capture this data, a research capacity and productivity survey of members of the RCCSS(C) was conducted and a scoping review investigated the research productivity of the Canadian sports chiropractic field over a five-year period from January 2015 to January 2020.[10]

While the research capacity and productivity survey and scoping review provided quantitative data about the field's capabilities[10], previous authors suggest research capacity development (RCD) is a complex topic that requires consideration of many factors that cannot be characterized by quantitative methods alone[11,12]. Additionally, RCD operates within interconnected health research systems that often include interactions between various system levels that include individual researchers, investigative teams, and organizations that operate within health and social care structures.[12–14] To provide a broader understanding of research capacity across these interconnected levels, the collection of both quantitative and qualitative data is recommended.[11,12] This present manuscript reports on the second part of a qualitative study that interviewed sports chiropractic researchers and leaders to investigate the challenges and opportunities for RCD in the sports chiropractic field.

Methods

This manuscript reports on part two of a research project that utilized a qualitative description study to explore research priorities (part one) and investigative capacity (part two) in sports-focused chiropractic research. Part one of this project, along with detailed reporting of the methodology contributing to both parts of this qualitative study, is reported in our previous published report.[5] This manuscript outlines our general approach and reports unique methodological components for part two. We direct readers to the part one publication[5] for details about the study design, eligibility criteria, participants, interview settings, and data collection procedures.

Study design

We conducted a cross-sectional qualitative description study using semi-structured interviews of sports-focused chiropractic researchers and focus group interviews of organizational leaders of sports chiropractic in Canada. Qualitative description is a study design applied in qualitative research when the aim is to acquire a rich description from participants about a phenomenon under study without the need to develop substantive theory or explanations from the data.[15,16] It often utilizes purposive sampling to identify participants who possess the appropriate lived-experience for the phenomenon under study, semi-structured and/or focus group interviews for data collection, and qualitative content analysis to identify themes and categories of participant descriptions. Qualitative description is a relevant study design for those aiming to gain first-hand knowledge of professionals' experiences with a particular topic, and has been applied previously to explore participant descriptions about challenges, facilitators, and barriers.[16,17] Considering the aim of this study (part two) was to explore sports chiropractic professionals' descriptions about the challenges and opportunities for RCD in the sports chiropractic field, this study design was chosen.

Participants and eligibility criteria

To be eligible as a participant for the semi-structured interview component of this study, participants had to be registered chiropractors or researchers who have either conducted, been a collaborator, or supervisor of sports-focused chiropractic research and who have also published at least one sports-focused research paper within the past 10 years. To be eligible for the focus group interview component of this study, participants had to be either a current board member of the RCCSS(C) or its Foundation. Purposive and snowball sampling were used to identify participants that met our selection criteria and who

would yield appropriate and useful information for the aim of this study.[18] For further detail about the sampling approach utilized, we refer readers to the part one publication[5] of this study.

Research team and reflexivity for Part Two

The interviews were conducted by two members of the research team (ADL - male, LD - female). At each interview, another member of the research team (MB - female or KS - female) attended (in person, virtually, or by telephone) to take notes. Qualitative coding and analysis were conducted by three members of the research team (ADL, LD, and AM – male). At the time of this study, ADL and LD were practicing chiropractors, fellows of the RCCSS(C) and full-time faculty members at the Canadian Memorial Chiropractic College. AM was a practicing chiropractor and a resident of the RCCSS(C). Note takers KS and MB were a practicing chiropractor and fourth year chiropractic student at the Canadian Memorial Chiropractic College, respectively.

Considering the sports chiropractic field is a relatively small field of study, pre-existing relationships within the field exist. At the time of data collection and analysis, ADL, LD, and AM were involved in committee work with the RCCSS(C) and ADL and LD were actively involved in the sports-focused chiropractic research field. As a result, they have previous relationships with some of the participants who were interviewed. To mitigate any bias that may have occurred during the interviews, the interviewers regularly met before each interview to reiterate the study's aim and purpose. During the qualitative analysis, ADL, LD and AM aimed to decrease their own bias by regularly meeting to reflect on their coding decisions in relation to the study's aim.

Setting and interviews

The semi-structured interviews were conducted in-person or remotely using the Skype Application (Skype Technologies, Microsoft, USA), dependent on the availability of the participants. Two separate focus group interviews of the organizational leaders of sports chiropractic in Canada were conducted in-person: one for the Board of Directors of the RCCSS(C) and another for the Board of Directors of the Foundation for the RCCSS(C). These focus group interviews were conducted in a meeting room at the location of the RCCSS(C) Annual Board Meeting. Three members of the research team were present at both focus group interviews. The lead author (ADL) moderated the focus group while LD and MB took field notes. The interview guide was informed by our previous work that investigated the research needs and preferences of Canadian chiropractors practicing in sport,[4] and was distributed to members of the Research and Education Committee of the RCCSS(C) for feedback related to the questions developed and their relevance to our research question. The same interview guide was used for both the focus group and semi-structured individual interviews. All participants were sent our interview guide,[5] a minimum of two days in advance of their interview, to provide them with the opportunity to familiarize themselves with the questions and to allow them to consider potential responses. For further detail about the setting and interviews, we refer readers to the part one publication[5] of this study.

Analysis for Part Two

A qualitative content analysis of the interview transcripts was conducted using an interpretivist perspective. The intention of an interpretivist approach is to describe and interpret, but not to develop a substantive theory. It is concerned with how people feel, respond and give meaning to their experiences.[19] Since we did not seek to develop theory from the data or compare and contrast the viewpoints of the participants, the semi-structured interviews of the researchers and focus-group interviews of the leaders were given equal weight in our analysis. The unit of analysis were the interview transcripts from each participant.

Three members of the research team coded the transcripts for part two of this qualitative study (AL, LD, and AM) using an inductive content analysis for both manifest and latent content. The coders regularly met for peer debriefing to discuss and resolve any coding discrepancies. Similar codes were sorted and collapsed together to create categories. Themes were abstracted from the codes and categories generated from the data with guidance from previous research that investigated frameworks for RCD in allied health professions.[8,12] An audit trail of the coding and reflexive process was recorded throughout the analysis. The qualitative analysis and reporting of the data was guided by the consolidated criteria for reporting qualitative research.[20]

Research ethics approval

This study received approval by the Canadian Memorial Chiropractic College (CMCC) Research Ethics Board (#1708E01, approval date 09/14/2017) prior to commencement. All participants signed a written informed consent form before the start of each semi-structured or focus group interview.

Results

Participants

For the semi-structured interviews, 25 sports-focused chiropractic researchers were recruited (22 from purposive and 3 from snowball sampling) and 20 participated (80% participation rate). For the focus groups, all 12 individuals recruited participated fully in the study (100% participation rate). A total of 32 participants completed this study. The average interview durations for the semi-structured and focus group interviews were 56.87 and 52.55 minutes, respectively. All participants reviewed and returned their transcripts to the research team, and 12 participants made minor revisions to clarify statements made in their interviews with no significant changes to the content. No new codes emerged from the data by semi-structured interviews 19 and 20. It was determined further interviews were unlikely to generate any significant new codes and themes from the targeted population and recruitment was concluded.[21]

Our sample had a larger proportion of males (78%), and there was large variability in the average years of practice and number of publications of our participants, demonstrating that participants had varying levels of clinical and research experience, respectively. Most participants held faculty positions (72%), had affiliations with chiropractic academic institutions (66%), and maintained a clinical practice (78%). Nearly all participants were chiropractors (97%), and 59% had some form of sports specialization training. Of the participants, 29 (90%) reported having post-graduate research training (master's degree or higher). Reflective of our sampling strategy, our sample was comprised of 21 (66%) Canadians and 11 (34%) from other countries. We refer readers to Table 1 from our part one publication[5] for further reporting of the demographic characteristics of our participants.

Major themes

Our qualitative analysis identified four major themes: 1) affiliations and collaborations, 2) human resources, 3) financial resources and 4) operational resources. Each major theme was divided into subthemes organized by the challenges and opportunities to develop research capacity in sports-focused chiropractic research (Figure 1).

Affiliations and collaborations - challenges

The affiliations and collaborations theme emerged from the data to categorize codes related to facilitating, establishing, and maintaining research affiliations and collaborations. Participants voiced concern that research affiliations and collaborations within the sports chiropractic field were lacking. Several described profession-specific issues, such as being a small "insular" research group, the division within the profession, and the negative perception of the chiropractic field as current challenges to build research collaborations, as conveyed in the quotes below.

> *"You have to engage with many other professions, and many other researchers…the reason for that kind of thinking is you'll never be funded by national funding agencies because you're too insular, you're too within yourself, and you're not broad-based across the entire healthcare spectrum." (Semi-structured Interview Participant 18 - SSP18)*

> *"I think we have chiropractors [who] are all about building their own castles, and they're not about building a city, and if you build your own castle you're never going to build a city because you live in your castle and you think it's perfect and you're the king of the castle, and actually the whole city out there, no one realizes actually the person in the castle's actually not bad and I think that's the problem we've got as a profession." (SSP18)*

> *"…there is still a lot of anti-chiropractic sentiment and those are the stories that university people hear when they start to look into our profession." (SSP18)*

Participants recommended shifting the current approach to a more collaborative mindset and to seek research opportunities with others outside of the field, such as in academia, sports organizations, and other healthcare and scientific disciplines.

Figure 1.
Themes and subthemes of challenges (blue) and opportunities (grey) for research capacity development in the sports chiropractic field.

> *"…it needs to be more collaboration, it needs to be…research groups…where you have one chiropractor amongst…many other people, and so larger groups…more collaborative." (SSP12)*

Some respondents reported that since many chiropractic academic institutions are not integrated within publicly funded universities alongside other healthcare education programs, this siloed academic environment can decrease the opportunities for interprofessional collaboration.

> *"I'm at [major university]…I think [there are] 22 different professions that we teach, but of course not chiropractic…it's very easy for medical doctors, to nurses, to physiotherapists, occupational therapists, speech therapists to do a lot of research and work together because they are so used to being in one environment where they have been educated together." (SSP16)*

A lack of knowledge of the profession and its sports subspecialty was reported as a challenge to build research collaborations.

> *"The problem that I encountered…is no one knows what [chiropractic college] is, no one knows what a DC [Doctor of Chiropractic] is, and I apologize again, nobody knows what a sports fellowship is." (SSP18)*

Affiliations and collaborations – opportunities

Despite these challenges, participants described areas of opportunity within this theme. These were categorized into the subthemes, *collaborative action* and *collaborations to pursue*. Collaborative action was defined as activities conducted with the intent to foster and develop research affiliations and collaborations. These actions included networking, relationship building, communication, and incentivizing collaborations.

> *"I think we need to establish unofficial contacts with people that we have identified that we want to work with, the groups we want to work with…to come into bigger projects." (SSP12)*

> *"Go to conferences like the ACSM [American College of Sports Medicine] and just strike up conversations with people who are researchers at other institutions who might have similar interests to you…you'd be surprised how often those types of collaborative networks start to develop because of a conversation that you just had in passing with somebody at a conference." (SSP4)*

> *"…it means that you have to put in a bunch of time working on other people's projects…the idea is that when you do that, then they help you along with yours." (SSP13)*

A strategy offered by some participants involved facilitating affiliations and collaborations through strategic funding to incentivize collaborations.

> *"What kind of money do we have in order to approach some other organizations? Maybe we can form some partnerships in that sense." (SSP3)*

> *"Whatever it takes to create that relationship. It's probably going to cost a bunch of money. It probably would require you know, a donation." (SSP13)*

Working in a collaborative setting has its advantages as it facilitates the opportunity to share information, thoughts, and ideas between researchers. Participants recommended the field pursue a variety of collaborations to advance the research capabilities of sports chiropractors.

> *"The first thing I would do is try to find collaborations which goes outside chiropractic because I think this is the problem…why do we have to do sports chiropractic research and not sports research?" (SSP12)*

> *"…it's becoming more and more the way that research goes, it's becoming more and more multi-disciplinary kind of approach to studying a particular problem or question." (SSP4)*

Participants described the importance and value of working with key groups, such as researchers from major universities and those from the medical profession.

> *"…major universities and medical practitioners, they have the resources, they have the money…they have the contacts, so being able to team up in these fields, would be the best for us." (Focus Group 2 Participant 4 – FG2P4)*

Other opportunities to build affiliations included working with those in the sports community and with practicing chiropractors working in sport.

> *"I think that if we can collaborate with the clubs, essentially the people who are looking after the athletes…that would automatically involve other members of the sports delivery team, so that will become a multidisciplinary or interdisciplinary process." (SSP15)*

> *"…any project you had in mind, you could quadruple the size of it by engaging field practitioners across the country…but we've gotta create that infrastructure." (SSP1)*

> *"Great field practitioners are not necessarily ever going to be researchers, but their knowledge base and their connections are what's important." (SSP8)*

Building research teams within the profession was also reported as an important opportunity to pursue, especially with other specialities within the chiropractic profession.

"…we can definitely start by collaborating intra-professionally…like collaborating with our clinical specialists and radiology specialists and the other specialties in Canada." (FG1P6)

Human resources - challenges

The human resources theme was defined as the research workforce of a field of study and includes both researchers and support staff. A challenge identified within this theme was an overall lack of researchers and the staff that support them, such as research mentors, assistants, and statisticians.

"To have the team to be able to support the research, whether it's lab focused, whether it's the statisticians, whether it's the research assistants to help the accessibility." (FG1P2)

"You need to have a role model, you need to have somebody who can actually help you and assist you." (SSP12)

The lack of sports chiropractors with a PhD designation was identified as a key challenge to advance RCD for the field. Not only can those with PhD training conduct research, but they also play an important role in the ability to communicate and build relationships with other researchers and academic institutions.

"We really [have a] complete lack of PhDs in sport chiropractic." (FG1P7)

"Without a PhD there is not common ground between the university sector and our profession… You really need to have a PhD in order to speak their language…to get the access and the credibility to the funding." (SSP18).

"If some of our people had PhDs in nutrition, a PhD in sports psychology, a PhD in sport performance…that to me, at the very least, improves substantially the perception that chiropractors are experts in sports injury and sports-related issues." (SSP18)

The lack of a facilitated pathway for sports chiropractors to obtain high degree research (HDR) training was another challenge reported. The sacrifices that clinicians need to make to obtain a HDR degree was described by some participants as daunting.

"I don't know how easy it is to take somebody into a DC [Doctor of Chiropractic Training Program], and then now they're a hundred grand in debt, and then go to grad school. I mean they could, but that structure needs to exist to make it more streamlined." (SSP1)

"My trials and tribulations were that I was working full time and trying to go to school part time… as a consequence it took me longer than traditional grad students to get through both my Masters and my PhD basically…at the end of the day it was still stressful for me to like have that weight on my shoulders for literally years…I wish I could have maybe in some way, reduced my hours at work, but not lost my income." (SSP5)

A challenge reported included a lack of protected time for clinicians to conduct research. Participants reported the sports chiropractic profession is typically comprised of clinicians whose interest is focused on clinical practice and not research. While clinicians may have an interest in conducting research, the benefits of this rarely outweighed the risks of taking time away from practice to earn an income and from personal/family life.

"I think we're all desperately trying to work and treat patients in our clinics. We're then going off and working in sports environments on top of what we're doing already, and then we've got our family life." (SSP15)

"Time is one thing because…if you are in practice and teaching and stuff, time to do that [research] is always short." (SSP17)

Human resources - opportunities

Opportunities identified by participants to develop the human resources to support research included focusing on researcher development, access to support staff, protected research time, and incentives. To facilitate researcher de-

velopment, participants emphasized the need to identify research talent early, provide a pathway for HDR training for those with talent, and incorporate research requirements into sports chiropractic training programs.

> *"We really need to look out for those people who are interested in actually doing this kind of research full-time". (FG1P6)*

> *"We need to build an academic pathway to make sure chiropractors are doing research in universities…we need more DC, PhD." (SSP19)*

> *"…get the residents in some sort of cooperative program…where a person could get their fellowship and their MSc side by side…get them the skills that they need to be productive researchers." (SSP7)*

Participants discussed the importance of building a "pipeline" of research talent and providing a system of mentorship linking them with senior researchers.

> *"You need to have that kind of cycle, or that pipeline, and I've seen it work in several labs where the senior researcher has a group of PhDs, so postdocs, that work underneath them, then they [postdocs and PhD students] act almost as mentors to the master's students. The master's students act as almost mentors to the undergrads that are working in the labs. Often times, what ends up happening is those undergrads end up becoming master's students and the master's students become PhD students." (SSP4)*

Creating mechanisms to facilitate a pathway for those with research interest to obtain HDR skills and degrees was a strategy described by participants.

> *"Support them with some sort of fellowship to sort of give them the ability…to remain in practice, or work at [chiropractic academic institution]…go to school and still be a professional making some income." (SSP5)*

> *"…if we had our own internal research pathways…then there's a natural flow of chiropractic through that research machine. The school is producing master's and PhD students, that research agenda is inherent to the institution, their training is complimentary to it, and they're automatically bringing some clinical knowledge to it, which a bachelor's student does not." (SSP1)*

Having qualified researchers does not necessarily translate into producing research. To further advance research capacity, our participants discussed other opportunities to advance the human resources of the sports chiropractic field. In addition to developing researchers, staff that support the research effort should be developed, opportunities for providing clinician-researchers with protected time to conduct research should be explored, and incentives can be provided to motivate individuals to conduct research. Incentives that were discussed ranged from offering reduced membership renewal fees for those who conduct research to providing recognition and awards.

> *"I wish someone could say, 'hey, [employer] that for the next whatever year, you'll be at work from 8 to 1 then from 1 to 5 you, you have release time to do whatever'…but not lose my, my full-time income." (SSP5)*

> *"…for a research type thing, maybe there can be…a leeway in registration price if you're helping out with a research project." (SSP3)*

Financial resources - challenges

The financial resources theme was applied to categorize codes related to funding the sports chiropractic research field. Financial resources were described as critical for supporting the capacity to conduct research.

> *"I think that acquiring funding is the biggest issue." (SSP8)*

A lack of funding in the form of research project grants was reported as a key challenge and understanding the funding lines to support sports-focused research for chiropractors was reported as a factor to advance the research potential for the sports chiropractic field.

"If we really want to make serious headway, serious progress, then we really have to look at the funding lines for sport chiropractic research. To date, we know that's very low and that's the reality of not seeing the significant type of research we want to have done being completed…getting the budgets for sports chiropractic research to happen are key." (FG1P6)

Participants also discussed the limited funds available to support research infrastructure and the minimal financial support for attending research conferences important for networking.

"Feasibility and accessibility of equipment…just knowing who has what equipment and where, and how do you get the ability to use the equipment and at what fee. So, it comes back to money again." (FG1P5)

"I have to fund my own research and I don't have finances to travel…I can't ask my wife to give up another holiday, another vacation this summer, because I'm going to the [research conference], so I've never gone." (SSP9)

Lack of compensation for the time and effort required to conduct research can discourage researchers, especially clinician-researchers from further involvement in research. Interviewees voiced their frustration with the lack of compensation for their research efforts, and the limited research career opportunities available for clinician-researchers to have a funded partial research workload.

"The clinician-researcher, I think is super valuable, but it's difficult to do it in a way that doesn't cost the person performing that research money and stress, and cost to their family." (SSP1)

"I've published five papers out of the goodness of my heart…I didn't get a dime. In fact, I spent money on it." (SSP1)

"…the goal I see for us, to improve in research is to have people who are well paid to do that." (SSP14)

Financial resources – opportunities

While the lack of financial resources was described as a challenge, participants offered strategies to improve the financial resources of the research effort. These opportunities were categorized into two subthemes – *funding actions and pursue funding opportunities*. The experienced researchers interviewed recommended aligning the field's research agenda with those of funding agencies to increase the likelihood of success for obtaining grants from these agencies.

"Pick the one or two institutes that are most closely aligned with sports chiropractic, look at their focus, look at the things they want to research, look at their language, adopt their language as part of your research perspectives and research agenda, so the likelihood of you getting funding dollars in a competitive process from the institute is good." (SSP18)

"The funders, the deciders of who gets the money, they need to be convinced that you're not just a special interest group of a dozen or so people sitting around a table saying well let's research sports chiropractic. It has to be geared to, how do we advance the interests of Canadians…that's kind of like an overall kind of perspective to have." (SSP18)

To address the funding limitations discussed, participants emphasized the importance of having a foundation dedicated to raising money to fund the sports chiropractic research effort. It was suggested a foundation could offer research grants, fund PhD training opportunities, and invest in infrastructure. Having an active research foundation was thought to be a central strategy to address the field's research funding challenges.

"You need a foundation that is actually active and raising funds…and has an arm that is distributing those [funds] to the active chiropractic researchers out there, and the funds that are getting distributed, they've got to be meaningful." (SSP7)

"…being able to provide some grantsmanship type money for those interested individuals to move on

in their academic career, and then utilizing those people to come back and help support the sport chiropractic field from a research standpoint." (FG1P7)

Another funding action that was emphasized was the importance of collaborating with experienced researchers/institutions to increase the likelihood of obtaining research funding.

"Collaborating with a university where you could get funding and just easier access to different equipment or things like that, might be just easier to conduct research." (FG1P4)

"Finding and collaborating with those who are already within an area that has funding…or has a niche area where an institute is funded, and funding can come via the institute." (SSP10)

As for the subtheme pursuing funding opportunities, participants provided suggestions for funding sources to pursue. These included government sources, industry, membership fees from sports chiropractic associations, and private donors. The high reward but difficulty with success at obtaining government research grants was discussed by an experienced research administrator (SSS18).

"…if you're just going to go after a hundred dollars here and a hundred dollars there, then every year you're just going to have a group of sports-related chiropractors sitting around a table discussing research and that maybe fine, but what are you going to do for thirty-five million [inhabitants of a country] who are in desperate need of sports chiropractic and don't even know who you are?" (SSP18)

"one of the next steps for your group would be to compare your research perspectives and priorities to those of the provincial and national federal funding agencies, they're the ones with the dollars, everyone is chasing them, although the success rates are very low, you have to get into the process…because that's where the credibility is and the big bucks are, without the big bucks you won't go very far." (SSP18)

The opportunities for establishing relationships with organizations and corporations of the sports industry was also recommended.

"…sports organizations that really like chiropractors…[we can] say, ' Hey! Why don't you make a donation to our research fund, so that we can do more research to find ways to, you know, improve performance, decrease the probability of injuries, find ways to speed up the treatment that your chiropractor does.'" (SSP11)

Participants also recommended sports chiropractic associations dedicate a portion of their membership fees to help fund the sports chiropractic research effort.

"… those people who are joining or are members of the national sports chiropractic associations actually pay into a fund that can then pay for its own research." (SSP15)

The importance of building long-term relationships with potential private donors was also described, especially building rapport with those with the capability of making meaningful contribution amounts.

"You need to develop relationships right across [country] with personal individuals who are willing to donate to meet your agenda, that's why the words in your agenda are very important." (SSP18)

Operational resources - challenges

Operational resources refers to the physical and non-physical resources that support the research effort, such as the research infrastructure and its supporting processes. The current challenges identified in this theme included a lack of access to physical resources in the form of research equipment and laboratories, and difficulty accessing supportive services, such as library access, research ethics boards, and statisticians.

"I feel like being a clinician in practice, now that I don't have a connection to an institution, I have

no ability to do research because I don't have any access to databases." (FG1P5)

"For somebody who's not affiliated with an institution and is interested in research, knowing that an REB [Research Ethics Board] can be accessed… for that [research] ethics piece." (FG1P2)

Participants also described the limitations of the quality and type of research that the sports chiropractic field can conduct, due to the current capacity of its operational research resources. Specifically, some participants discussed the difficulty of conducting randomized clinical trails.

"You need some pretty good infrastructure to do a randomized controlled trial. You need to be able to pull the people into the study and get the numbers you need in the timeframe." (SSP9)

Another identified challenge was an uncoordinated research strategy. Since the sports chiropractic field has limited resources with relatively few full-time researchers, participants voiced concern over the impact of an uncoordinated research strategy on such a small field of study. Participants emphasized the importance of having a coordinated plan to minimize wasting the limited research resources available.

"I think we have to be really clever and really collaborative about what we do and how we do it, because we've got so limited resources, and we've got so few people that can actually pull this off." (SSP15)

Operational resources – opportunities

The opportunities to improve the operational research resources included developing a research agenda and strategic plan, creating a research chair or centre for the sports chiropractic field, establishing practice- and field-based research networks, and improving knowledge transfer by creating a dissemination network. In keeping with the concern about obtaining research funding and minimizing research waste, participants described the importance of creating a research agenda and strategic plan to inform fundraising and to ensure research resources are responsibly allocated.

"Developing a research agenda is very important because that helps establish the plan." (FG1P7)

"So, we're all clearly finding that the funds are key, but obviously we also need to have that plan in place. If we can put the plan in place that will help support the funds, I mean it's going to be hard to go after the funds without a plan." (FG1P6)

An opportunity that participants believed was important to advance the sports chiropractic field, was to create a sports chiropractic research chair and research centre within a university setting. Participants described this as an excellent mechanism to fund a full-time researcher to implement the research agenda and provide the system to create a pipeline of researchers to develop graduate students.

"I think the first thing that you really need to establish is a chair or a centre, and preferable a chair in a centre…the centre for sports chiropractic research and it needs to be within an institution you know that has a research drive to it. Then somebody who is sitting in the chair that is really going to drive that bus." (SSP7)

"Let's pick one of these provincial universities that has a good program in sports medicine…let's put in a new chair in sports chiropractic research, let's create fellowships that drive more people there." (SSP11)

In addition to creating a research centre and/or chair, another opportunity discussed was to create a mechanism where researchers and field practitioners can collaborate in a structured way to bring "clinical practice closer to research", and vice versa. The suggestion for doing so was to create practice- and field-based research networks. Participants believed this would be a mechanism to increase the involvement of clinicians in the research effort, contributing to increasing research capacity.

"…to allow your field practitioners to collect data at a competition level would be very valuable, but

also at a practice level, trying to get some practice-based research going, I think would actually really help with capacity issues." (SSP7)

Participants stressed practice-based research cannot occur without researchers and clinicians working together, and often these two groups do not collaborate effectively without a formal structure in place to facilitate this valuable interaction.

"We seem to have our researchers over in one corner and our field practitioners over in the other corner. The researchers say, 'gee it would be nice to get out and get some data from, you know, sporting events and what we do', and the sports practitioners saying, 'gee it would be nice to convert what I do into some research.' And they are not talking. We need to be able to deliver a platform for field practitioners to translate their experience into research…we need to set up practice-based research networks at the "country" level and at the "international" level." (SSP6)

Another opportunity to improve the operational resources of the sports chiropractic research effort, was to improve the dissemination of research to improve knowledge transfer, especially to clinicians who are not affiliated with an academic institution. Suggestions for improvement in this area included creating more formalized dissemination strategies for knowledge sharing.

"I think that people that are not in an institution have no idea what research is out there, what people are looking to do." (FG1P5)

"The [research conference] serves as pretty much the touch point for almost all collaborative work within the chiropractic profession…there is probably a rationale for a separate body that would just look at sports research between all the chiropractic colleges." (SSP13)

Discussion

To our knowledge, this is the first qualitative study investigating the research capacity of the sports chiropractic field. Our analysis identified four themes related to the challenges and opportunities for RCD in sports chiropractic – 1) affiliations and collaborations, 2) human resources, 3) financial resources, and 4) operational resources. The main challenges for affiliations and collaborations, were a lack of research collaborations and the influence of profession-specific issues when building collaborations. Pursuing collaborations and collaborative actions, such as communication, networking, and relationship building, were key areas of opportunity. For human resources, challenges included a lack of researchers, support staff, time to conduct research, and limited sports chiropractors with HDR training. Opportunities for improvement were related to researcher development strategies, providing research support staff, facilitating protected time to conduct research, and providing research incentives. Regarding financial resources, a lack of funding was a key challenge, specifically related to grants, infrastructure, conferences, career opportunities, and training. Opportunities to advance financial research resources were related to funding actions and pursuing funding options. Key challenges for operational resources were a lack of access to research resources and not having a coordinated research strategy. Creating a research agenda/strategic plan, a research chair/centre, practice- and field-based research networks, and improving dissemination were opportunities identified in this area. These findings will inform an RCD strategy for the sports chiropractic field.

Advancing the research capacity of a health profession is important to address health challenges and support evidence-based care.[1,2] While established health professions, such as medicine, have implemented and evaluated RCD strategies, many allied health professions are underdeveloped in this area. Recognizing this challenge, Matus *et al*.[8] conducted a systematic review to develop a consolidated framework for RCD for the allied health professions. This framework consists of three major themes: 1) supporting clinicians in research, 2) working together, and 3) valuing research for excellence. To "support clinicians in research", the framework emphasizes education and training, mentoring/coaching, access to resources, protected time and funding, reward and recognition, and support to undertake post-graduate HDR. To "work together" in research, areas of focus include collaborations and partnerships, shared purpose and drivers, team-based research projects, and shared expertise. Strategies for "valuing research for excellence" include providing visible support

for research, committing to research as core business, prioritizing research that is "close to practice", and integrating local research findings back into practice. This consolidated framework provides a roadmap for RCD for allied health professions.

The results of our present study revealed the sports chiropractic field exhibits research capacity characteristics similar to the framework for RCD by Matus *et al*.[8] In our study, the opportunities to support researcher development for the sports chiropractic field included research talent identification, creating HDR training pathways, providing research support staff, providing protected research time, and offering research incentives. Matus *et al*.[8] identified similar strategies in their "supporting clinicians in research" theme, such as education and training, protected time and funding, reward and recognition, and support to undertake post-graduate study including HDR. Other similarities were discovered in our "affiliations and collaborations" theme that emphasized the importance of collaborative actions and pursuing collaborations. This is similar to the "working together" theme from Matus *et al*.[8] Moreover, within their "valuing research for excellence" theme, Matus *et al*.[8] described concepts, such as "prioritization of research that is close to/relevant to practice" and "integration of local research findings back into practice". In our study, participants recommended the creation of practice- and field-based research networks. An essential purpose of practice-based research networks is to conduct research that is close to or relevant to practice and to disseminate the research findings back to the practices that conducted the research to close the knowledge to practice gap.[22–24] The similarities between our findings and the consolidated framework by Matus *et al*.[8], provides initial evidence that the sports chiropractic field exhibits similar research capacity features as other allied health professions.

While understanding RCD within the setting of a health profession is valuable, developing research capacity to optimize research impact requires consideration of RCD in a broader context. It involves applying RCD across interrelated components of a health research system, coordinating RCD amongst researchers, research institutions, stakeholders, and health and social care systems. To develop such guidance, Cooke[11–13,25] conducted RCD investigations within a publicly funded collaborative applied health research partnership to develop an evidence-based Framework for Research Capacity Development for Impact (RCDi)[13]. This framework was designed to inform RCD in people, organizations, and the wider health research system to plan, develop, and execute impactful research.[13] It is comprised of structural levels (the individuals, organizations, and health & social care systems in which research development activity occurs) and six capacity building principles that "cut across" these structural levels (skills and confidence building, co-production, actionable dissemination, infrastructure, linkages and collaborations, sustainability and leadership, and ownership and responsibilities).[13] Interpreting our study's findings within this framework, our "affiliations and collaborations" theme included elements consistent with Cooke's "linkages and collaborations" principle.[13] Our "operational resources" theme identified parallels with Cooke's "infrastructure" principle,[13] and our "researcher development" subtheme aligned with Cooke's "skills & confidence building" principle[13]. The recommendation to create a research chair and centre aligns with Cooke's "sustainability and leadership" principle[13], and the recommendation to create practice- and field-based research networks and a dissemination network is consistent with Cooke's "actionable dissemination" principle[13].

As described by various authors[12–14], RCD is complex and operates at various structural levels ranging from individuals, teams, organizations, and the overall health system. Our analysis revealed that many of our themes and subthemes also cut across structural levels of a research system. For example, individuals with research talent must be identified and mentored by researchers and research teams (individuals and teams), funding bodies (organizations) must provide the finances to facilitate post-graduate training pathways for aspiring researchers (individuals), academic institutions or healthcare organizations (organizations) must provide career opportunities for those who obtain such skills (individuals), and granting opportunities for researchers (individuals and teams) should be available to conduct research to influence policy (sports and healthcare systems). Since many of our findings are in line with the frameworks by Cooke[12,13] and Matus *et al*.[8], our results can be utilized alongside these frameworks to inform an RCD strategy for the sports chiropractic field.

While our results provide preliminary evidence the sports chiropractic field exhibits similar challenges and

opportunities for RCD as other health professions, we did identify findings unique to the sports chiropractic context. Many participants cited profession-specific issues, such as the negative perception of the chiropractic profession and the profession's own internal divisiveness as challenges to build research affiliations and collaborations. The tendency of the chiropractic profession to be perceived as being "siloed" and the lack of knowledge of the profession were expressed as challenges affecting collaborative activity. Our previous research capacity survey[10] found only 18% of active sports chiropractic researchers were involved in a collaboration outside of their academic institution. Despite these limited research collaborations, many participants in this present study emphasized the importance of building collaborations to advance research capacity. This finding is consistent with a Canadian sports chiropractic research prioritization Delphi study, where the top six research priorities in the first Delphi round were related to building research collaborations.[6]

Other findings unique to the sports chiropractic field centered around human research resources. A consistent challenge emphasized by participants was a lack of full-time researchers and those with PhD qualifications. This finding is supported by our sports chiropractic research capacity survey that found only 1.8% of its survey participants reported having a PhD degree, with a similar amount being full-time researchers.[10] Our interviewees in this present study emphasized the importance of supporting clinician-researchers. They cited a lack of protected time to conduct research, and the difficulty clinicians have in obtaining HDR training due to the competing priorities of clinical practice, time, and personal responsibilities. These findings are in line with our previous work that found the Canadian sports chiropractic research effort is primarily conducted by part-time clinician researchers, whose research training is primarily obtained through sports chiropractic fellowships (69%) with some obtained from master's degree programs (24%).[10] Strategies are required to develop PhD qualifications amongst sports chiropractors and support them with full-time research opportunities.

Strengths, limitations and future research

A strength of our study was the use of semi-structured and focus groups interviews to investigate research capacity. This provided the opportunity to study the complexity of research capacity that cannot be fully explored with quantitative methods alone. Another strength was our diverse sample of participants that included a mix of interviewees of various ages, experiences, academic roles, and geographical regions. Despite obtaining a sample of participants that conducted sports-focused research, our study did not investigate the perspectives of stakeholders of the sports chiropractic field, which can be a focus of future research. Another limitation is our study did not directly investigate research culture. Validated instruments have been developed to assess research culture amongst individuals, teams, and organizations. Future investigations can apply these tools to study the research culture of the Canadian sports chiropractic field. Additionally, recent literature has recommended the identification and development of indicators to study the process of RCD operating in a research system.[11,12] In this study, we identified themes and subthemes specific to RCD for the sports chiropractic field, but did not investigate their prevalence or prioritization. Future work can utilize these themes to develop field-specific RCD indicators and interventions. Mixed methods and consensus procedures can be applied to investigate and prioritize these items to inform their incorporation into an overall research strategy, and quantitative studies can provide outcome data on their effectiveness.

Conclusion

As part of the "Advancing the Research Effort for Canadian Sports Chiropractors Initiative", this study provides specific and detailed insight about the challenges and opportunities for RCD for the Canadian sports chiropractic field. To advance research capacity, our qualitative data supports increasing fundraising efforts to secure sustainable funding, expanding research affiliations/partnerships through collaborative actions, creating HDR training pathways for clinician-researchers, enabling research activity by providing support staff and research time, aligning the research agenda with funder/stakeholder priorities, establishing a research chair/centre, and formalizing partnerships between clinicians and researchers through practice-based research networks. Additionally, our findings indicate the sports chiropractic field exhibits similar RCD features outlined in RCD frameworks for allied health professions.[8,12,13] Given this alignment, these RCD frameworks[8,12,13] can be applied to the Canadian sports chiropractic field within the context of the RCD

data obtained from this current study, along with research development data obtained from other studies[4–6,10] of the "Advancing the Research Effort for Canadian Sports Chiropractors Initiative". Integrating these data sources to inform research strategy development, will increase the potential for Canadian sports chiropractors to make meaningful contributions as research partners in society.

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Prevalence of low back, pelvic girdle, and pelvic floor complaints in pregnant elite athletes: a narrative review

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Objective: *To investigate the prevalence of low back, pelvic girdle, and pelvic floor complaints in pregnant elite athletes.*

Background: *Common symptoms during pregnancy include low back pain, pelvic girdle pain, and pelvic floor dysfunction. There has been minimal investigation around the prevalence of these musculoskeletal disorders in the pregnant elite athlete.*

Methods: *A narrative review was conducted using electronic databases and hand reference searching. Articles were screened based on the inclusion/exclusion criteria.*

Results: *727 articles were retrieved digitally, while hand and reference searching yielded one article. After removing those that did not fit the inclusion/exclusion criteria, there were a total of three articles.*

Prévalence de plaintes au bas du dos, à la ceinture pelvienne et au plancher pelvien chez les athlètes de haut niveau enceintes: une revue narrative

Objectifs: *Enquêter sur la prévalence de plaintes au bas du dos, à la ceinture pelvienne et au plancher pelvien chez les athlètes de haut niveau enceintes.*

Contexte: *Les symptômes courants pendant la grossesse sont la douleur au niveau du bas du dos, la douleur au niveau de la ceinture pelvienne et un dysfonctionnement du plancher pelvien. Il y a eu peu d'enquêtes sur la prévalence de ces troubles musculo-squelettiques chez les athlètes de haut niveau enceintes.*

Méthodes: *Une revue narrative a été réalisée en utilisant des bases de données électroniques et des recherches manuelles de références. Les articles ont été examinés en fonction des critères d'inclusion ou d'exclusion.*

Résultats: *Un total de 727 articles ont été récupérés numériquement, tandis que la recherche manuelle et la recherche de références ont donné un article. Après avoir retiré ceux qui ne répondaient pas aux critères d'inclusion ou d'exclusion, il restait au total trois articles.*

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Summary: *Prevalence of these conditions in pregnant elite athletes is variable within the literature. The values appear to change based on trimester, parity, and description of these conditions. Similarly, frequency, duration, and type of exercise may also influence the prevalence. Further investigation is warranted to help guide safe participation in elite sport activity during pregnancy.*

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KEY WORDS: athlete, elite, exercise, pregnant, low back pain, pelvic girdle pain, pelvic floor dysfunction, chiropractic

Résumé: *La prévalence de ces conditions chez les athlètes de haut niveau enceintes varie selon les études. Les valeurs semblent varier en fonction du trimestre, de la parité et de la description de ces conditions. De même, la fréquence, la durée et le type d'exercice peuvent également influencer la prévalence. Une enquête plus approfondie est nécessaire pour orienter une participation sécuritaire à une activité sportive d'élite pendant la grossesse.*

(JCCA. 2024;68(3):204-213)

MOTS CLÉS : athlète, élite, exercice, enceinte, douleur au niveau du bas du dos, douleur au niveau de la ceinture pelvienne, dysfonction du plancher pelvien, chiropratique

Introduction

Common symptoms during pregnancy include low back pain (LBP), pelvic girdle pain (PGP), and pelvic floor dysfunction (PFD), including urinary incontinence (UI) and fecal incontinence (FI).[1-4] Pregnancy-related LBP is defined as pain located between the costal margins and the inferior gluteal folds, while PGP is pain in the symphysis pubis and/or between the posterior iliac crest and gluteal folds.[5] UI and FI are defined as any involuntary leakage or loss of urine and loss of flatus, liquid, or solid stool, respectively.[6,7] UI has been further categorized as either stress urinary and urge incontinence.[6] Stress UI is involuntary leakage with effort of exertion, or during sneezing or coughing.[6] Urge incontinence is involuntary leakage accompanied by or immediately preceded by urgency.[6] The prevalence of these conditions during pregnancy is high. Approximately 20-90% of pregnant individuals experience pregnancy-related LBP, 20% suffer from PGP, 3-29% FI, and 9-75% UI.[5,8-10]

Muscular strength and endurance training before pregnancy may have a positive influence on prevention and treatment of these conditions in the pregnant population.[11-16] However, there are some inconsistencies surrounding those who participate in high-level sport and determining if their activity level is in fact preventative, a risk factor, or if it is due to the type of activity.[17-22] Prior to pregnancy up to 80% of elite athletes may experience LBP and UI depending on the type of sport participation.[20, 21, 23] Elite athletes who participate in greater than eight hours of exercise a week, may be at greater risk for developing both UI (33% higher) and FI (15% higher) compared to the general exercising population before pregnancy.[24] Currently there is no research to date investigating the prevalence of pre-pregnancy PGP in elite athletes.

The 2019 Canadian Exercise and Pregnancy guidelines recommend the following exercises for the general population: strength training, aerobic activity, pelvic floor muscle strength training, and stretching/yoga.[25, 26] The exercise recommendations described in this guideline do not account for the high levels of training that an elite athlete may endure preconception and during gestation.[25,27,28] Similarly, the International Olympic Committee (IOC) Exercise and Pregnancy in Recreational and Elite Athletes guidelines do not mention any recommendations on training frequency or duration of exercise in the elite pregnant population.[13, 29-31] The IOC recommends that pregnant elite athletes may use perception of exertion or fatigue to gauge their training intensity.[29] The recommendations state that athletes should refrain from training greater than 90% of their max oxygen consumption (VO2 max) and from doing strenuous strength training to avoid the Valsalva manoeuvre, which can lead to increased pressure on the pelvic floor.[29] In addition, the IOC suggests that if a pregnant elite athlete trains above the current recommendations there is an assumed level of risk.[29] This is due

to the high intensities, volumes, durations, and specific types of exercise training, which have yet to be supported as safe practice during gestation.[29]

The term "elite athlete" has been poorly defined within the literature. A definition of "elite" used within pregnancy related studies is "a person who is a member of any national team or other high-level representative team in any sport organized by a National Sports Federation", however this definition does not define the training level of an elite athlete.[32] A systematic review of seventeen studies demonstrated that the average training by an elite athlete was 6.5 hours per day and 5.7 times per week.[33] This training frequency is much higher than the 150 minutes over 3 days recommended for the general pregnant population in the 2019 Canadian Guidelines for Exercise and Pregnancy.[26] Elite athletes may continue to participate in high-level sport and training as they enter and progress through pregnancy.[32, 34] Considering the prevalence of LBP, PGP and PFD is comparable in some elite athletes before pregnancy with the general pregnant population, it is possible that pregnant elite athletes would be at risk for an increased preva-

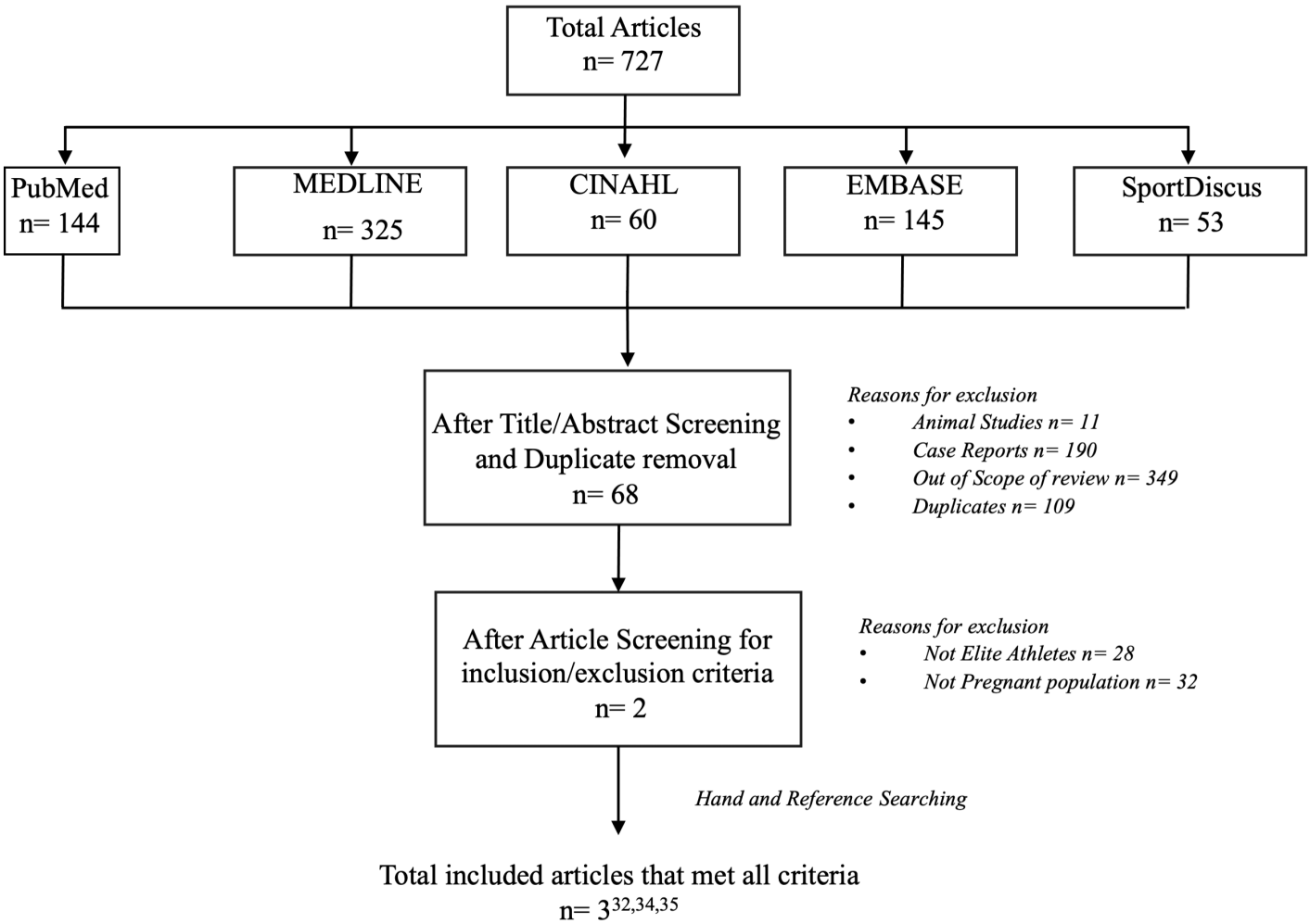

Figure 1.
Screening process

lence of these conditions, however at this point it is unknown.[8-10, 20-23] To date, there has been minimal research investigating the prevalence of LBP, PGP, and PFD in pregnant elite athletes. The aim of this narrative review is to investigate the prevalence of LBP, PGP, UI, and FI in pregnant elite athletes compared to those who are less active during their pregnancy.

Methods

A search was performed in PubMed, MEDLINE (Ovid), EMBASE (Ovid), SportDiscus (EBSCO) and CINAHL (EMSCO) on all articles until July 27, 2023, with the aid of a reference librarian. Reference searching of any retrieved articles and hand searching was also employed. Search terms used were, but not limited to, "athletes" AND "elite" AND "exercise" AND "pregnancy" AND "low back pain" AND "pelvic girdle pain" AND "pelvic floor dysfunction". An example search strategy, employed in PubMed, can be found in Appendix 1. One reviewer selected the relevant papers by examining titles first, then abstracts, followed by full text. The quality of the included articles was assessed using the SIGN checklist. The screening process is outlined in Figure 1.

Results

The screening process is outlined in Figure 1. There was a total of 727 articles retrieved digitally, which were exported to Microsoft Word for reference management and tracking of the screening process. After removing duplicates, screening titles, and abstracts, a total of sixty-eight articles remained. Hand and reference searching yielded one article.[35] After removing articles that did not fit the inclusion and exclusion criteria (Table 1), a total of three articles remained.[32 34,35] Of the three articles, one was a systematic review and two were retrospective observational studies (Table 2).[32,34,35] The two retrospective studies were included in the systematic review.

Table 1.
Inclusion and exclusion criteria

Inclusion Criteria	**Exclusion Criteria**
Published in English in a peer-reviewed journal	Articles not published in English
Experimental (Randomised Clinical Trials), observational (Cohort and Case-Control) studies and systematic review/meta-analysis that compare elite female athletes to a control group	Articles not published in peer-reviewed journals
Elite female athletes of any gestational age	Participants sought out treatment outside the scope of the study, such as spinal manipulation, acupuncture, or other manual therapies
Elite female athletes experiencing low back pain with or without leg pain, pelvic girdle pain and/or pelvic floor dysfunction (urinary and/or fecal incontinence)	Animal studies
Elite female athletes ages 18-45 who are pregnant	
Elite female athletes that compete with a national team or other high-level representative team in any sport organized by a National Sports Federation before and during pregnancy	

Table 2.
Included papers: prevalence of LBP, PGP, UI, and FI during pregnancy

Author, year	Subject, parity	Study Type	Control Group	LBP	PGP	UI	FI
Bo K and Backe-Hansen KL, 2007[32]	Pregnant elite athletes (primiparous)	Observational	Age-matched controls, less active, same parity	No rad: 18.5% With rad: 14.8%	*33.3% ** 29.6% ***22.2%	SI: 18.5% UI: 7.1% MI: 3.2%	----------
Sundgot-Borgen J, *et al*., 2019[35]	Pregnant elite athletes (primiparous and multiparous)	Observational	Age-matched controls, less active	1st TM: 0% 2nd TM: 12% 3rd TM: 12%	1st TM: 3% 2nd TM: 9% 3rd TM: 9%	----------	----------
Wowdzia JC, *et al*., 2021[34]	Pregnant elite athletes (primiparous)	Systematic Review	Age-matched controls, less active, same parity	----------	Sundgot-Borgen J: 1st TM: 3.57% 2nd TM: 10.71% 3rd TM: 10.71% Bo K and Backe-Hansen KL: 74.19%	Sundgot-Borgen J: Not reported Bo K and Backe-Hansen KL: 23.91%	----------

TM = trimester; rad = radiation; *PGP = pubic symphysis pain ; ** = PGP (SIJ): ***PGP = pubic symphysis and SIJ; SI = stress incontinence; UI = urge incontinence; MI = mixed incontinence.

Discussion

There has been minimal research investigating the prevalence of LBP, PGP, and PFD in pregnant elite athletes. The reported prevalence of these conditions is variable within the literature. Bo and Backe-Hansen were the first authors to investigate the prevalence of LBP, PGP, and PFD in primiparous pregnant athletes compared to age matched controls using a retrospective survey study design.[32] The study had a 77.5% and 57.5% response rate from the elite athlete group and the age matched controls respectively.[32] The prevalence of LBP was found to be 14.8% in those with radiation and 18.5% in those without radiation, while the prevalence in controls was reported to be 28.3% and 32.6%, respectively.[32] PGP was delineated by region, which included pain in the pubic symphysis, sacroiliac joints, and both areas combined.[32] The prevalence was found to be 33.3%, 29.6%, and 22.2% in pregnant elite athletes and 30.4%, 26.1%, and 15.2% in controls, respectively.[32] Similarly, UI was differentiated into the following types, urge incontinence, stress incontinence, and mixed incontinence.[32] The prevalence was found to be 7.1%, 18.5%, and 3.2% in elite athletes and 8.7%, 15.5%, and 2.2% in controls.[32] Lastly, no elite athletes reported FI during pregnancy, however the prevalence in controls was found to be 2.2%.[32] Bo and Backe-Hansen reported no significant differences in the prevalence of LBP, PGP, or PFDs in elite athletes when compared to age matched controls during pregnancy.[32]

Sundgot-Borgen *et al*. 2019, used a questionnaire to ask 34 Norwegian elite primiparous and multiparous athletes and 34 less active controls various health related questions, including those related to musculoskeletal

conditions.[35] All participants in the study had been pregnant in the previous five years.[35] The authors looked at prevalence during the first, second, and third trimesters.[35] The prevalence of LBP in elite athletes was found to be 0%, 12%, and 12%, while the prevalence in controls was found to be 12%, 21%, and 38%, respectively.[35] A significant difference was noted during the third trimester compared to controls; however no significant difference was noted at any other time points throughout pregnancy for the prevalence of LBP.[35] prevalence of PGP.[35] However, the prevalence was reported to be approximately between 3-9% in pregnant elite athletes and between 0%-15% in controls.[35]

A 2021 systematic review and meta-analysis by Wowdzia *et al*.[34] reported on the prevalence of PGP and UI in primiparous pregnant elite athletes. After pooling the total events of PGP from Bo and Backe-Hansen[32], they found the prevalence to be 74.19% in elite athletes and 71.73% in controls[34]. Using Sundgot-Borgen *et al*.[35], the authors removed the multiparous elite athletes to solely examine the primiparous elite athletes[34]. Wowdzia *et al*.[34] found the prevalence of PGP in primiparous elite athletes during trimesters one, two, and three to be 3.57%, 10.71%, and 10.71%, respectively. The prevalence in controls during the first, second, and third trimester was reported to be 0%, 10.34%, and 17.24% respectively.[34] Lastly, they reported the prevalence of UI based on pooled total events from Bo and Back-Hansen[32] to be 22.58% in pregnant elite athletes, while it was 23.91% in controls[34]. The authors concluded that there were no significant differences in the prevalence of these conditions compared to age matched controls.[34] This systematic review concluded that elite athletes have a 62% reduction in the odds of experiencing pregnancy-related LBP compared to age matched controls, however the authors classified it as low certainty of evidence.[34] They also demonstrated no association between preconception competitive sporting exposure of PGP and UI in elite athletes.[34] This was classified as very low certainty of evidence by the authors.34 Due to a minimal number of studies, small sample sizes, and high bias linked to the studies included in Wowdzia *et al*.'s[34] systematic review, the authors deemed the quality of evidence low for these subgroup complaints.

It appears that prevalence values may be influenced by trimester, parity, and description of these conditions. The included studies are not consistent when controlling for these variables. As seen in Bo and Backe-Hansen[32], they included specific descriptions of LBP, PGP, and UI while Sundgot-Borgen *et al*.[35] was non-specific. Furthermore, Bo and Backe-Hansen[32] reported prevalence results for LBP and PGP were not contingent on trimester, whereas Sundgot-Borgen *et al*.[35] specifically looked at prevalence of LBP and PGP during the three trimesters. Lastly, Bo and Backe-Hansen[32] included singleton pregnancies, while Sundgot-Borgen *et al*.[35] included singleton and multiparous pregnancies. These factors may contribute to the variability in the reported prevalence results due to inconsistent categorization of the conditions, changes in biomechanics throughout the trimesters, and parity.

Training frequency, duration, and type of sport (high vs low impact) are all factors that may impact the prevalence of LBP, PGP and PFD.[17-22] Wowdzia *et al*.[34] did not comment on training or sport participation of the elite athletes they were investigating. Bo and Back-Hansen[32] found that the mean training hours in the elite athlete group was recorded at 14 hours/week before pregnancy. This is less than the reported average training of 6.5 hours per day and 5.7 times per week reported in a 2014 systematic review looking at elite athlete training before pregnancy.[33] Bo and Backe-Hansen[32] also reported that a significant number of elite athletes complete specific strength training exercises for the abdominal and back muscles during pregnancy. There was no difference found between elite athletes and age matched controls for pelvic floor strength training during pregnancy.[32] Sundgot-Borgen *et al*.[35] found that both endurance and strength training volume were significantly higher in the elite athletes compared to controls before and during pregnancy. Before pregnancy, elite athletes participated in approximately 750 mins/week of endurance training and 115 mins/week of strength training.[35] This frequency of training is comparable to the frequency reported by Bo and Backe-Hansen.[32] During pregnancy, elite athletes participated in 550-700 mins/week of endurance training and 55-90 mins/week of strength training, with the training time varying based on trimester of pregnancy.[35] The type of sport was not documented by the athletes who completed either survey, leaving no indication if high versus low impact sports were of high participation.[32, 35]

Limitations

The authors of this narrative review recognize that there are limitations including uncertainty if the pain reported by the athletes in the studies was indeed due to their pregnancy and not due to a previous injury/pathology. The type of sport participation was not identified in the included studies, which may skew the results. The term "elite athlete" is poorly defined in the literature. A standard definition that includes training intensity, frequency and duration fails to exist. Lastly, the quality of the studies included in the review are of low to moderate quality. They had poor sample sizes, high heterogeneity, were observational retrospective survey studies, and used only those living in Norway.

Conclusion

With minimal high-quality research available, it appears that the prevalence of LBP, PGP, and PFD in pregnant elite athletes is variable. The prevalence appears to change based on trimester, parity, and description of these conditions. Similarly, frequency, duration, and type of exercise may also lead to the variability in the reported prevalence numbers. Due to a lack of studies on this topic, definitive conclusions cannot be drawn. As more and more elite athletes continue participating in high-level sport and training throughout their pregnancy, there is a need for further investigation surrounding the prevalence of these conditions in pregnant elite athletes in order to provide the necessary information to support these athletes' safe participation in sport at an elite level.

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Appendix 1.
PubMed search strategy

((((((“Intervertebral Disc/injuries”[Mesh])) OR (“Intervertebral Disc Degeneration”[Mesh] OR “Intervertebral Disc Displacement”[Mesh])) OR (“Osteoarthritis, Spine”[Mesh])) OR (“Spinal Injuries”[Mesh])) OR (“Spondylolysis”[Mesh])) OR (“Synovial Cyst”[Mesh])) OR (“Spinal Curvatures”[Mesh])) OR (“Polyradiculopathy”[Mesh])) OR (“Zygapophyseal Joint/injuries”[Mesh])) OR (“Spinal Diseases”[Mesh])) OR (“Spinal Stenosis”[Mesh]))) AND ((lumbar*[Title/Abstract] OR (low back[Title/Abstract]) OR low-back*[Title/Abstract] OR (lower back[Title/Abstract]) OR lower-back*[Title/Abstract] OR thoracolumbar*[Title/Abstract] OR thoraco-lumbar*[Title/Abstract] OR lumbosacral*[Title/Abstract] OR lumbo-sacral*[Title/Abstract] OR sacral*[Title/Abstract] OR sacro-iliac*[Title/Abstract] OR sacroiliac*[Title/Abstract]))) OR ((((((((((((((((((((((((((((“Low Back Pain”[Mesh]) OR (“Back Pain”[Mesh])) OR (“Back Injuries”[Mesh:NoExp])) OR (“Back Muscles/injuries”[Mesh])) OR (“Lumbar Vertebrae/injuries”[Mesh])) OR (“Lumbosacral Plexus/injuries”[Mesh])) OR (“Lumbosacral Region/injuries”[Mesh])) OR (“Piriformis Muscle Syndrome”[Mesh])) OR (“Sacrococcygeal Region/injuries”[Mesh])) OR (“Sacroiliac Joint/injuries”[Mesh])) OR (“Coccyx/injuries”[Mesh])) OR (“Sacrum/injuries”[Mesh])) OR (“Sciatica”[Mesh])) OR (lumbar disk extrusion[Title/Abstract] OR lumbar disk degeneration[Title/Abstract] OR lumbar disk herniation[Title/Abstract] OR lumbar disk prolapse[Title/Abstract] OR lumbar disk protrusion[Title/Abstract] OR lumbar disk avulsion[Title/Abstract] OR herniated lumbar disk[Title/Abstract] OR slipped lumbar disk[Title/Abstract] OR prolapsed lumbar disk[Title/Abstract] OR degenerated lumbar disk[Title/Abstract] OR extruded lumbar disk[Title/Abstract] OR protruded lumbar disk[Title/Abstract] OR avulsed lumbar disk[Title/Abstract] OR lumbar herniated disk[Title/Abstract])) OR (lumbar pain[Title/Abstract] OR lumbar facet[Title/Abstract] OR lumbar nerve root[Title/Abstract] OR lumbar 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incontinence[Title/Abstract] OR fecal incontinence[Title/Abstract])))) OR (((pelvi* pain*[Title/Abstract]) OR (pelvi* injur*[Title/Abstract]) OR (pelvi* ach*[Title/Abstract]) OR (pelvi* myalg*[Title/Abstract]) OR (pelvi* symptom*[Title/Abstract]) OR (pelvi* syndrome*[Title/Abstract]) OR (pelvi* discomfort*[Title/Abstract]) OR (pelvi* sore*[Title/Abstract]) OR (pelvi* impairment*[Title/Abstract]) OR (pelvi* disorder*[Title/Abstract]) OR (pelvic floor dysfunction*[Title/Abstract]) OR (pelvi* dysfunction*[Title/Abstract]) OR (pelvi* tear*[Title/Abstract]) OR (pelv* imping*[Title/Abstract]) OR (pelvi* sprain*[Title/Abstract]) OR (pelvi* strain*[Title/Abstract])) OR (pfd[Title/Abstract]))) AND ((((((((((("Pregnancy"[Mesh]) OR ("Pregnant Women"[Mesh])) OR ("Pregnancy Outcome"[Mesh:NoExp])) OR ("Pregnancy Complications"[Mesh:NoExp])) OR ("Prenatal Care"[Mesh])) OR ("Parturition"[Mesh])) OR (antenatal[Title/Abstract] OR "ante natal"[Title/Abstract] OR ante-natal[Title/Abstract] or 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Management of persistent patellofemoral pain conditions using a tricompartmental offloading knee brace: a case series

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Objective: *To describe the utility of a tricompartmental offloading knee brace as an adjunct intervention for managing persistent PFP conditions.*

Clinical features: *Three cases of active adult females with persistent PFP following non-response to conventional and guideline aligned management strategies are presented.*

Intervention and outcomes: *Patients were managed using a tricompartmental offloading knee brace alongside individualized exercise programs for up to 12 weeks. Subjective and objective measures of pain and function were measured at three distinct time points. Each patient reported decreased pain, increased activity tolerance, and demonstrated improvements in both strength and functional performance over the course of the intervention period.*

Gestion des conditions persistantes de douleur patellofémorale à l'aide d'une attelle de genou à effet de décharge tri-compartimentale: une série de cas

Objectifs: *Décrire l'utilité d'une attelle de genou à effet de décharge tri-compartimentale en tant qu'intervention complémentaire pour la gestion des conditions persistantes de douleur patellofémorale.*

Caractéristiques cliniques: *Trois cas de femmes adultes actives présentant une douleur patellofémorale persistante (DPP) après une non-réponse aux stratégies de gestion conventionnelles et des lignes directrices de stratégies de gestion alignées sont présentées.*

Intervention et résultats: *Les patientes ont été prises en charge à l'aide d'une attelle de genou à effet de décharge tri-compartimentale en parallèle à des programmes d'exercices individualisés pendant un maximum de 12 semaines. Les mesures subjectives et objectives de la douleur et de la fonction ont été évaluées à trois moments distincts. Chaque patiente a signalé une diminution de la douleur, une augmentation de la tolérance à l'effort et a démontré des améliorations tant au niveau de la force que du rendement fonctionnel au cours de la période d'intervention.*

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Summary: *The use of tricompartmental offloading knee bracing alongside exercise therapy may be effective for the management of persistent PFP and should be considered for active adult females if unresponsive to both conventional and guideline aligned treatments.*

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KEY WORDS: patellofemoral pain, PFP, management, offloading knee brace, knee orthoses, case series, chiropractic

Résumé: *L'utilisation d'une attelle de genou à effet de décharge tri-compartimentale en parallèle avec une thérapie par l'exercice peut être efficace pour la prise en charge de la douleur patellofémorale persistante et devrait être envisagée chez les femmes adultes actives si elles ne répondent pas aux traitements conventionnels et harmonisés aux lignes directrices.*

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MOTS CLÉS : douleur patellofémorale, DPP, prise en charge, attelle de genou à effet de décharge, orthèses du genou, série de cas, chiropratique

Introduction

Patellofemoral pain (PFP) is a non-specific pain condition of the anterior knee. It is characterized by generalized pain in the peripatellar or retropatellar regions during activities of lower limb loading, such as squatting, running, stair ascension/descension, sports participation, and prolonged sitting.[1] PFP affects individuals across the entire lifespan, regardless of sex or activity level[2], with an annual prevalence rate of around 25% commonly reported[3,4]. The one-year prevalence of PFP within female populations is frequently observed to be nearly double that of males[4], with the point prevalence of PFP among female adolescent athletes reported to be as high as 28%[5].

A prominent theory explaining the underlying cause and development of PFP is that chronic compressive overload of the patellofemoral interface may contribute to deleterious changes to the structure and function of retropatellar articular cartilage.[6,7] While a direct link between PFP and pathology of the patellofemoral joint (PFJ) remains elusive, mechanical overload of articular cartilage has been demonstrated to inhibit pro-adaptive capabilities, leading to substantial structural damage of articular cartilage in chronically overloaded environments.[7,8] This evidence lends credence to the belief that PFP may exist as a prodromal syndrome to degenerative conditions of the patellofemoral joint, such as retropatellar chondrosis and patellofemoral osteoarthritis (PFOA).[9,10] As such, it has been proposed that pain-based diagnoses such as PFP should accompany structural diagnoses that may not outright explain pain symptoms, when appropriate or observable.[11]

Clinical practice guidelines (CPGs) have been developed specifically for the management of PFP, which recommend that practitioners utilize management strategies such as exercise interventions that target the musculature of both the knee and the hip, patellar taping, foot orthoses, gait retraining, and patient education.[1] In addition, many non-guideline adherent management strategies are also frequently used by allied healthcare professionals, including patellar bracing[12,13] and referral for intra-articular injections[14]. Despite best practice interventional strategies, as many as 40% and 56% of patients diagnosed with PFP continue to report pain at 12-months[15] and 24-months[16] respectively, with more than 50% of individuals reporting poor outcomes five to eight years after initiating care[17]. A potential pitfall with many of these best practice interventions is that they fail to sufficiently mitigate the excessive PFJ forces hypothesized to be driving the condition, instead solely addressing the pain response or indirectly modifying joint loads.

Cases of PFP that fail to respond to traditional and CPG-recommended management strategies may, in fact, require a much more direct approach to dissipating compressive joint forces within the PFJ. While strategies such as complete rest, immobilization, and activity cessation may achieve the largest degree of articular cartilage offloading, they are often not feasible nor ideal management options as the reduction in muscle activation may contribute to muscle atrophy and strength loss while also underloading patellofemoral cartilage below the threshold required to stimulate positive adaptations. Tricompartmental offloading knee braces may offer a solution to

this problem by achieving sufficient patellofemoral joint offloading while simultaneously permitting patients to remain active and increase periarticular muscle strength and hypertrophy. This style of knee brace is designed to decrease joint contact forces by providing an assisted knee extension moment.[18] The Levitation® knee brace (Spring Loaded Technology) is one such brace, utilizing a hydraulic spring embedded within the frame of the brace to generate a passive extension moment (Figure 1), which increases linearly with increases in knee flexion angles.[19] This has been shown to reduce quadriceps muscle force requirements during dynamic tasks[20,21], contributing to decreased compressive forces across the patellofemoral joint[18,20] and providing pain relief in both immediate- and long-term follow-up periods in patients with PFOA[21,22]. The purpose of this case series is to describe the utility of the Levitation® knee brace as an adjunct intervention alongside exercise therapy for managing persistent PFP conditions in a heterogeneous sample of female patients who were unresponsive to guideline-supported management strategies.

Case series

We describe three cases of active adult females who presented to a multi-disciplinary knee clinic for the management of persistent unilateral PFP after not responding to

Figure 1.

The Spring Loaded Levitation® tricompartmental offloading knee brace. A rigid, step through knee orthoses which utilizes an embedded hydraulic spring to generate a passive extension moment.

conventional and guideline aligned management strategies. Each patient was prescribed a custom-fitted Levitation® knee brace and an individualized home exercise program designed to strengthen the musculature surrounding the knees and hips. Pain and function were monitored using a numerical pain rating scale (NPRS), a PFP-specific questionnaire (KOOS-PF), and a 30-second sit-to-stand test, as recommended by CPGs.[1] Additionally, a floor-anchored dynamometer (Exsurgo® gStrength™) was used to measure peak isometric knee extension forces with the patient seated with a 90° knee flexion angle. Patients attended two follow-up sessions between four and 12 weeks post-baseline, where outcome measures were reassessed, and exercise programming was progressed based on individual needs.

Case 1

An 18-year-old female former competitive gymnast presented with a 15-month history of right anterior knee pain and crepitus. She reported constant burning to sharp peri-patellar pain with concomitant allodynia over the anteromedial aspect of the knee, which restricted her participation in both competitive and recreational activities. Her symptoms emerged nine months following medial patellofemoral ligament (MPFL) reconstructive surgery at 16 years-of-age, performed due to a history of recurrent patellar dislocations. She rated the peak daily intensity of her pain as 8/10 on the NPRS, with aggravating factors including squatting, running, and stair ascension. Frequent episodes of painful knee catching, crepitus, and swelling, as well as occasional pain-related giving-way, were reported. Previous management for this complaint included prescription NSAID medications, therapeutic knee exercises, patellar mobilizations, and patellar repositioning knee braces, all without meaningful improvements. Orthopaedic follow-up dismissed further surgical intervention as a viable management option. Her self-reported goal of care was to improve her exercise tolerance to allow for a return to participation in recreational sporting activities.

Upon examination, the patella was observed to be positioned centrally, with visible atrophy of the vastus medialis oblique muscle (VMO). Active and passive knee flexion and extension ranges of motion (ROM) were full and symmetrical to the unaffected limb, with pain recreated during active knee extension and both active and passive knee flexion. Resisted knee extension at both 0° and 45° of knee flexion also recreated the presenting complaint, as did sit-to-stand and squat functional tasks. Excessive tissue tension of the rectus femoris muscle was palpated, and increased sensitivity of the tissues overlying the VMO and medial femoral condyle, suggestive of hyperalgesia and allodynia, were noted via digital palpation in comparison to the contralateral limb. No neurological deficits were identified. Patellar compression, grind, and apprehension orthopaedic tests all reproduced the presenting complaint, and a 9/9 Beighton Score was observed. Right knee radiographs demonstrated patella alta and trochlear dysplasia with no definitive degenerative changes, while magnetic resonance imaging demonstrated post-surgical development of full-thickness chondral denudation over the patellar apex and medial patellar facet.

The patient was diagnosed with right knee PFP secondary to post-surgical patellar facet chondrosis. A plan of management consisting of patellar mobilization, myofascial release therapies, and electroacupuncture was initiated at a frequency of twice per week for four weeks with sporadic patient follow up over eight additional weeks. A knee and hip focused home exercise program was also prescribed at a frequency of three to four times per week.

After 12 weeks of management, the patient reported minor improvements in pain and function, with no meaningful clinically important difference (MCID) achieved on the NPRS[23] or the KOOS-PF.[24] At this point, the Levitation® knee brace was prescribed to more directly decrease PFJ compressive forces and lessen knee pain during tasks of daily living and physical activity. The patient was instructed to wear the brace during periods of standing, ambulation, and exercise, including the continuation of her home exercise strengthening program. On the day of brace fitment, a series of patient-reported and functional outcome measures were administered (Table 1). These outcome measures were re-administered at 4- and 8-week follow-ups.

After four weeks of intervention using the Levitation® knee brace as an adjunct to strengthening exercises, the patient reported her peak knee pain over the previous week to have decreased to 4/10 on the NPRS, with decreased knee stiffness, pain, and PFJ crepitus while wearing the brace. She further reported the brace had allowed for improved adherence to her home exercise program and that decreases in both allodynia and hyperalgesia oc-

curred, which was confirmed via palpation of the anteromedial knee.

After eight weeks, the patient reported her peak knee pain over the preceding week to have further decreased to 3/10 on the NPRS, allowing for an overall increase in physical activity, including the resumption of short-distance running and recreational soccer. She further reported improved pain-free walking distance, increased pain-free squat depth, and zero pain during activities of daily living, even without the assistance of the knee brace. Over the course of the 8-week intervention period, improvements were observed in all outcome measures, meeting the MCID thresholds of 1.2 for the NPRS[23] and 16 for the KOOS-PF,[24] as well as the minimal detectable change (MCD) threshold of 2.5 repetitions for 30-second sit-to-stand[25] (Table 1). Absolute knee extension strength of the involved limb improved by 4.29 Kg (18.9%), and inter-limb strength symmetry increased from 73.6% to 82.8%. No additional therapeutic interventions were reported over the 8-week intervention period.

Table 1.
Subjective and objective outcome measures for Patient 1 at baseline, 4-weeks, and 8-weeks.

Outcome Measure	Baseline	4-weeks	8-weeks
NPRS	8	4*	3*
KOOS-PF	25.00	38.64	45.45*
Ipsilateral knee extension (kg)	22.62	20.99	26.91
Contralateral knee extension (kg)	30.75	29.98	32.50
30-second sit-to-stand (reps)	10	12	14‡

* = meaningful clinically important difference (MCID); ‡ = minimal detectable change (MDC).

Case 2

A 59-year-old female avid recreational skier and mountain biker presented with a ten-year history of progressive, insidious onset right anterior knee pain and crepitus. She reported sharp, activity-related retropatellar pain with generalized intermittent knee stiffness, which greatly limited her participation in all recreational sporting activities. No prior history of knee injury was noted. She rated the peak daily intensity of her pain as 3/10 on the NPRS, with aggravating factors including squatting, stair descension, and sit-to-stand tasks. The patient also reported morning stiffness of less than 30 minutes duration, post-activity knee swelling, and painful retro-patellar crepitus with a catching sensation upon weight-bearing knee flexion. Previous management for this complaint included intra-articular corticosteroid and viscosupplementation injections, therapeutic knee exercises, and multiple "off-the-shelf" and custom knee braces. Of all treatment modalities, only corticosteroid injections were reported to provide meaningful symptomatic relief. Her self-reported goal of care was to return to skiing, running, and mountain biking without pain-related limitations.

Upon examination, the patella was observed to be centrally positioned without obvious periarticular muscle atrophy or joint effusion. Active and passive knee flexion and extension ROM were full and symmetrical to the unaffected limb, with pain recreated by end-range flexion overpressure. Resisted knee extension recreated the presenting complaint, as did sit-to-stand and squat functional tasks. Tenderness upon palpation was elicited along the patellofemoral joint lines, and both patellar compression and grind orthopaedic tests reproduced the presenting complaint. Recent knee radiographs demonstrated severe osteoarthritis, isolated to the patellofemoral compartment of the knee.

The patient was diagnosed with PFOA with persistent right knee PFP. A plan of management consisting of the prescription of a Levitation® knee brace for use during physical activity, in addition to a hip- and knee-focused home exercise program to be performed at a frequency of three to four times per week for the duration of the study period, was initiated. Patient-reported and functional outcome measures were administered on the day of brace fitting, with these outcome measures re-administered at 6- and 12-week follow-ups.

After six weeks, the patient reported that her peak knee pain over the preceding week had increased to 6/10 on the NPRS following participation in a two-day ski camp. Despite the activity-related increase in pain, she reported that the brace was beneficial, noting that she could not have attempted the ski camp without it. She further reported having started running pain-free with the assistance of the knee brace before the pain flared up, an activity she was unable to do previously.

After 12 weeks, the patient reported that her peak knee pain over the previous week improved to 2/10 on the NPRS. She noted that she had returned to skiing as often as four times per week, with mild anterior knee pain onsetting only after consecutive ski days and resolv-

ing within 24 hours. She reported that her right knee felt stronger, citing the home exercise program and increased activity levels as the major contributors.

Over the course of the 12-week intervention period, improvements were observed in all outcome measures, however only the MCID threshold was met for KOOS-PF.[24] Absolute knee extension strength of the involved limb improved by 6.50 Kg (13.6%), and inter-limb strength symmetry increased from 73.7% to 91.0% (Table 2). The patient reported having received a corticosteroid injection, requisitioned by a sports medical physician, one day before the six-week follow-up, which led to noticeable and rapid pain reduction following her knee pain flare-up. No additional therapeutic interventions were reported during the 12-week intervention period.

Table 2.
Subjective and objective outcome measures for Patient 2 at baseline, 6-weeks, and 12-weeks.

Outcome Measures	Baseline	6-weeks	12-weeks
NPRS	3	6	2
KOOS-PF	47.73	61.36	63.64*
Ipsilateral knee extension (kg)	15.60	-	22.10
Contralateral knee extension (kg)	21.16	-	24.28
30 second sit-to-stand (reps)	16	16	18

* = meaningful clinically important difference (MCID); ‡ = minimal detectable change (MDC).

Case 3

A 55-year-old active female presented with a 20-month history of progressive, insidious left anterior knee pain and crepitus. She reported constant dull and achy retro-patellar pain, which limited her participation in her usual walking group and group exercise class activities. Her complaint first appeared following increased walking volume; no prior knee injury or surgery was reported. She rated the peak daily intensity of her pain as 8/10 on the NPRS, with aggravating factors including stair ascension and descension, deep knee flexion, and distance walking. She denied any instances of knee swelling, catching, or giving way. Previous management for this complaint included over-the-counter (OTC) pain medications, patellar mobilizations, patellar taping, patellar repositioning knee bracing, therapeutic knee exercises, and intra-articular viscosupplementation and platelet-rich plasma injections. Only rest from physical activity and OTC pain medication were identified to provide symptomatic relief. Her self-reported goal of care was to return to regular participation with her walking group, uninhibited by knee pain.

Upon examination, patellar lateralization was observed bilaterally with no obvious periarticular muscle atrophy or joint effusion. Active and passive knee flexion and extension ROM were full and pain-free bilaterally, with a positive patellar "J-sign" noted on the left. Resisted knee extension recreated the presenting complaint, as did single leg squatting to a depth of 45° knee flexion. Tenderness upon palpation was elicited along the medial and lateral patellofemoral joint lines, and both patellar compression and grind orthopaedic tests reproduced the presenting complaint. Ligament integrity tests of the knee and patella demonstrated no excessive joint laxity and recent knee radiographs demonstrated no evidence of osteoarthritis or other abnormalities.

The patient was diagnosed with left knee chondromalacia patella with persistent PFP. A plan of management consisting of using a Levitation® knee brace in addition to a knee- and hip-focused home-based exercise rehabilitation and strengthening program at a frequency of three to four times per week was prescribed. Patient-reported and functional outcome measures were administered on the day of brace fitment, with these outcome measures readministered at four- and nine-week follow-ups.

After four weeks of intervention, the patient reported her peak knee pain over the previous week to have improved to 2/10 on the NPRS, noting reduction in knee pain during flat-ground walking and both stair ascension and stair descension. She further reported greater pain-free walking distance and duration while wearing the knee brace.

After nine weeks, the patient reported her peak knee pain remained plateaued at 2/10 on the NPRS, with stair descension and squatting activities identified as the only mildly aggravating activities. Flat ground walking and stair ascension were no longer painful. She further noted a decreased dependence on the knee brace, using it only during strenuous walking and stair-climbing tasks, and had decreased her reliance on OTC medications for pain management both during and after activity.

Over the course of the nine-week intervention period, improvements were observed in all outcome measures (Table 3), surpassing the MCID thresholds for NPRS[23] and KOOS-PF,[24] as well as the MDC threshold for the

30-second sit-to-stand.[25] Absolute knee extension strength of the involved limb improved by 5.23 Kg (68.4%), and inter-limb strength symmetry increased from 38.1% to 50.4%. Other than OTC pain medication, no additional therapeutic modalities were reported during the nine-week intervention period.

Table 3.
Subjective and objective outcome measures for Patient 3 at baseline, 4-weeks, and 9- weeks.

Outcome Measure	Baseline	4-weeks	9-weeks
NPRS	8	2*	2*
KOOS-PF	25	68.18*	70.45*
Ipsilateral knee extension (kg)	7.65	10.34	12.88
Contralateral knee extension (kg)	20.10	25.55	25.56
30 second sit-to-stand (reps)	9	12	13‡

* = meaningful clinically important difference (MCID); ‡ = minimal detectable change (MDC).

Discussion

The management of PFP presents a challenge for clinicians, owing to a poor understanding of the specific tissues responsible for pain generation, a symptom-based diagnostic criteria, and a large degree of heterogeneity in case presentation.[1] The three cases detailed in this case series exemplify the heterogeneity often observed among female patients with PFP.[2,12,13] Despite overlapping diagnoses, the three patients varied with regards to age, activity level and type, symptom severity and duration, aggravating factors, and prior therapeutic approaches. This degree of heterogeneity may present a point of confusion for managing clinicians as few conditions present so consistently with such a diverse constellation of clinical features.

As each patient in the current report had previously undergone unsuccessful management efforts using a variety of techniques (the majority of which were supported by CPGs[1]), a decision to trial a Levitation® knee brace as an adjunct modality to regular care was made jointly between the providing clinician and the patient despite recommendations against knee orthoses in recent CPGs.[1] Current CPGs provide a recommendation against the use of knee braces, sleeves, and straps, based on the absence of high quality evidence to support these interventions.[1] Despite this, the decision to trial the Levitation® knee brace was made on the theoretical notion that the spring-loaded mechanism within the brace may reduce PFJ compressive loads, thereby reducing symptoms and improving exercise tolerance. Additionally, a paucity of reported or conjectural adverse or consequential effects of donning this type of brace further supported this decision.

During the course of management, each patient demonstrated functional improvements beyond the MCID as measured using the KOOS-PF (Tables 1-3).[24] Furthermore, two of the three patients demonstrated changes exceeding the MCID and MDC for the NPRS[23] and 30-second sit-to-stand test[25], respectively, whereas the third had initially presented with the most favourable pain and function levels of the cohort and thus experienced smaller relative improvements. Perhaps most importantly, all three of the patients reported successful completion of their pre-management goals of returning to activity without pain-based limitations and subjective satisfaction with their course of care. Of note, two patients were able to maintain pain-free activity despite decreased knee brace use, suggesting that long term reliance on the brace may not be necessary. As PFP is primarily a symptom-based diagnosis[1], measures of subjective symptom intensity and symptom-based functional limitations are key to understanding how patients progress through management plans.

Although not previously explored in PFP populations, the Levitation® knee brace employed in the current report has previously been demonstrated to provide symptomatic relief in multi-compartmental knee OA patients both in acute[21] and chronic[22] time scales. During braced conditions of a sit-to-stand task, knee OA patients demonstrated significantly reduced quadriceps muscle activity, patellofemoral and tibiofemoral joint loads and reported reductions in pain compared to non-braced conditions.[18,20] Modeling studies have also demonstrated that the spring-loaded mechanism found in this Levitation® knee brace provides a passive knee-extension moment sufficient enough to significantly reduce quadriceps tendon forces and compressive joint loads during active lower limb tasks.[19,20] As PFJ pressure is suspected to be a primary contributor to the presentation of PFP, authors have postulated that the unloading effect produced by this type of bracing solution may be appropriate for PFP patients in addition to those with multicompartmental knee OA.[20]

Although there is no current consensus on specific mechanisms underpinning the development of PFP,

leading hypotheses suggest that aberrant lower limb kinematics may play a role in the development of pathological patellofemoral joint loading patterns.[6,26] Increases in medial femoral rotation, hip adduction, and knee abduction during activities such as squatting, running, and stair climbing have been linked to both the presence[26-29] and development[30,31] of PFP. Furthermore, these kinematics, in addition to the presence of lateral patellar displacement and tilt, have been observed to decrease patellofemoral joint contact area, resulting in an increase in focal articular surface pressures.[26] Chronic increases in pressure on the retro-patellar surface have been suggested to overwhelm the pro-adaptive capacity of these structures, leading to articular cartilage overload and, eventually, structural damage such as that seen in PFOA.[6,26] Although an important distinction exists between PFP and PFOA from a diagnostic perspective, PFOA has repeatedly been suggested to be a sequela to PFP9,[32] and a relationship has been observed between individuals undergoing arthroplasty for PFOA and a history of adolescent PFP (OR = 2.31).[10]

Although the scope of this report prohibits concluding that the use of the Levitation® knee brace in the management of these patients is directly responsible for the positive outcomes, it provides a precedent for clinicians to consider the utility of this type of modality as an adjunct to regular conservative care of PFP cases. Additionally, it establishes a line of inquiry into the possible mechanisms through which the Levitation® knee brace may have interacted with the other components of the management plan of these patients to produce the favourable results measured.

Some clinicians may resist the prescription of spring-loaded braces out of fear that the assisted knee extension may precipitate further weakness about the joint due to muscular disuse. As a relationship has been observed between longitudinal changes in knee extension torque and the WOMAC scale (a questionnaire based patient reported outcome of knee osteoarthritis related pain and function),[33] concern for patients' force production capacity is founded. Specifically, a 3.7% decrease in quadriceps strength has been associated with MCID reduction in WOMAC scores on a 4-year follow-up of 2651 female knee osteoarthritis patients.[33] Although there are no longitudinal evaluations of the effect of this type of brace on quadriceps strength, all three of the patients presented in this report demonstrated increases in ipsilateral isometric knee extension torque (18.9%, 13.6%, 68.4%) as well as reductions in knee extension torque asymmetry. One potential explanation of this observation is that the patients experienced symptom relief from the brace to the extent that they were able to participate in their home-based and recreational exercise activities at intensities and volumes higher than otherwise possible. Although no specific measures of exercise adherence were employed in this study, all patients reported an improved subjective tolerance to exercise and volume of activity. This perspective may permit clinicians to consider the utility of tricompartmental offloading knee braces not as a remedy to the underlying pathomechanics of PFP, but rather as a supportive adjunct to an active care model.[34] Similar approaches are already commonplace in the management of PFP cases in the form of injection therapies, where various pain-relieving injectables are utilized for the express purpose of reducing pain and discomfort in an attempt to improve exercise compliance.[14]

Limitations

The heterogeneity present in the demographics and management of the three subjects discussed presents a major limitation of the current report. The subjects vary widely in age, structural diagnoses, primary activities, and previous therapeutic approaches. Furthermore, in addition to the bracing protocol and home-based rehabilitation program provided, the subjects differed greatly in the adjunct therapies they received during the study period. Although each patient received prescriptions for rehabilitation programs, the programs differed slightly between each patient, and no specific measure of exercise adherence was conducted. Patient 1 received manual therapy, including joint mobilizations, myofascial tissue release, and electroacupuncture, Patient 2 received a corticosteroid requisitioned by a sports medicine physician during week six of the 12-week study period, and Patient 3 self-medicated with over-the-counter NSAIDs for pain management. A further limitation is that the total study time differed between each case and was relatively short compared to the typical time course of the PFP condition, which may be ongoing for years.[15,16] As there was no control group present, it is difficult to conclude that the changes observed over the study period were a result of the interventions applied, or of natural history. As such, the

long-term effectiveness of the management plan cannot be assumed. Additionally, although peak knee extension strength appeared to increase in all three cases, the short follow-up period does not provide an indication of long-term strength adaptations in this population. Further investigations into the effect of long-term tricompartmental offloading knee brace use on pain, function, exercise adherence, and strength in a PFP population and potential adverse reactions are warranted.

Summary

This case series details the clinical experience of three active females diagnosed with PFP who were prescribed a Levitation® knee brace as an adjunct management tool alongside guideline-aligned hip- and knee-focused exercise therapy. Although knee orthoses are not recommended for managing PFP by CPGs, using an orthosis in these cases was justified due to the patients' lack of response to previous management strategies and the low-risk profile associated with knee bracing. The proposed relationship between elevated PFJ reaction forces and the development of PFP provides theoretical support for using a tricompartmental offloading knee brace in patients suffering from PFP. Bracing represents a low-risk adjunct to conventional treatment strategies in the management of chronic PFP cases. A previous study employing the Levitation® knee brace in multi-compartmental knee OA patients demonstrated trends towards decreases in activity-related pain and increases in total activity time over a nine-month period.[22] The inclusion of a tricompartmental offloading knee brace in the management of PFP may provide patients with increased opportunities to perform pain-free exercise and thereby improve compliance in first-line management strategies such as hip and knee strengthening rehabilitation programs.

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Misdiagnosed hamstring strain injury: a case report of early cauda equina syndrome

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Objective: *This case report discusses the diagnostic challenges associated with the early identification of cauda equina syndrome in a 25-year-old patient without lumbar spinal pain. It introduces a new classification scheme related to a more effective diagnosis.*

Clinical features: *The patient experienced pain in the right hamstring, diagnosed as a pulled muscle. Later, he experienced new symptoms of testicular pain and bladder issues.*

Intervention and outcomes: *Chiropractic treatments alleviated his right hamstring pain, albeit temporarily. Subsequently, new symptoms emerged, prompting the patient's referral to a local hospital. An MRI examination revealed a large lumbar disc herniation, leading to a microdiscectomy.*

"Présentation d'un syndrome précoce de la queue de cheval imitant une élongation musculaire de l'ischio-jambier: un rapport de cas"
Objectifs: *Ce rapport de cas aborde les défis de diagnostic associés à l'identification précoce du syndrome de la queue de cheval chez un patient de 25 ans sans douleur lombaire. Il introduit un nouveau schéma de classification lié à un diagnostic plus efficace.*

Caractéristiques cliniques: *Le patient a ressenti une douleur au muscle ischiojambier droit, diagnostiquée comme une élongation musculaire. Plus tard, il a ressenti de nouveaux symptômes de douleur testiculaire et de problèmes de vessie.*

Intervention et résultats: *Les traitements chiropratiques ont soulagé sa douleur au muscle ischiojambier droit, bien que temporairement. Par la suite, de nouveaux symptômes sont apparus, ce qui a conduit à l'orientation du patient vers un hôpital local. Une IRM a révélé une importante hernie discale lombaire, ce qui a nécessité une microdiscectomie.*

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Summary: *The reader will learn about a new classification of five different levels of CES. This classification is an important tool in clinical practice. This article also reviews critical information about the mixed neurological presentations of cauda equina syndrome, helping practitioners better understand these important clinical variants.*

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KEY WORDS: chiropractic, cauda equina syndrome, diagnosis

Résumé: *Le lecteur apprendra une nouvelle classification de cinq niveaux différents du syndrome de la queue de cheval. Cette classification est un outil important dans la pratique clinique. Cet article passe également en revue des renseignements essentiels sur les présentations neurologiques mixtes du syndrome de la queue de cheval, aidant ainsi les praticiens à mieux comprendre ces importantes variantes cliniques.*

(JCCA. 2024;68(3):224-232)

MOTS CLÉS : chiropratique, syndrome de la queue de cheval, diagnostic

Introduction

Cauda equina syndrome (CES) is a constellation of symptoms that primarily involves bladder and bowel dysfunction. Patients typically experience symptoms such as low back pain with unilateral or bilateral sciatica, fecal incontinence, bladder dysfunction, reduced sexual function, leg muscle weakness, and loss of sensation in the perineum, buttocks, and upper posterior thighs.[1] Historically, CES referred to the compression of the nerve roots below S1, especially S2, S3, S4 and S5.[2] In the literature, CES is a term associated anatomically and clinically with compression of the lumbar, sacral, and coccygeal nerve roots distal to the end of the conus medullaris.[3]

The primary cause of CES is lumbar disc herniation (LDH), and CES accounts for approximately 1-3% of LDH presentations. There are numerous other causes, such as spinal fractures, vascular lesions of the spinal canal, and complications from spinal anesthesia.[1] Regardless of the cause of CES, if symptoms appear abruptly, surgical decompression is required within 48 hours. After this time, there is an increased risk of permanent bowel, bladder, and sexual dysfunctions.[1] Therefore, early diagnosis is crucial to avoid the risk of such complications and potential litigation against the treating practitioner.[2]

CES has been reported as a rare complication of spinal manipulative therapy (SMT).[5] Between 2000 and 2011, six court decisions involving Canadian chiropractors allegedly causing CES following SMT were published.[5] Due to the wide range of clinical presentations of CES, the authors believe that early diagnosis of CES can easily be missed or delayed. The following case report of a young man presenting without low back pain illustrates the diagnostic challenge for a case of a lumbar disc herniation associated with early clinical symptoms of CES. The proposed classification scheme for CES is intended to help practitioners improve their diagnosis accuracy.

Case report

A 25-year-old university student visited a Student Outpatient Chiropractic Clinic complaining of a gradual onset of pain in the posterior right thigh for the past few weeks. He did not have any known cause for this pain and denied experiencing any lower back pain or symptoms below his right knee. He described the pain as a tight, painful sensation in his hamstring, worse in the morning and at the end of the day. The pain was exacerbated during his part-time job as a waiter in a restaurant, and when lying down on his back with his right leg straight. He experienced some relief by taking NSAIDs daily. The student was otherwise in good health and regularly engaged in weightlifting, boxing, and jogging.

The initial examination did not reveal any antalgic posture or gait disturbances. Lumbar spine range of motion was full and pain-free, except for some discomfort at the end range of flexion due to tightness of the hamstrings. Palpation of the right hamstrings (biceps femoris and semitendinosus) revealed increased muscle tension and pain. Motion palpation of the lumbar spine revealed joint restriction at the level of the L4-L5 vertebral segment in the left rotation plane. The straight leg raise test

was 70 degrees bilaterally without any signs of nerve root tension. The neurological examination did not show any significant findings, except for brisk and symmetrical deep patellar tendon reflexes (3+). Ankle clonus was not present and plantar response was down going. He was diagnosed with a possible right hamstring strain, likely from his gym workouts. Over four months, he received 12 chiropractic treatments, consisting of three separate sets of four treatments each.

The patient experienced a 95% improvement of his hamstring pain after undergoing the first four chiropractic treatments. These treatments included deep soft tissue therapy (without instrument-assisted soft tissue mobilization technique) targeting the right hamstrings, gluteal muscles, and iliopsoas. The patient was also treated with diversified SMT to address the lumbar spine and right SI-joint hypomobility. High-velocity low amplitude spinal manipulations were provided at the level of L4-L5 vertebral segment with the patient lying on his left side. He was given a home program of stretching exercises for his tight hamstrings.

A month after his first visit, he returned to the Clinic as he was experiencing increased pain in his right posterior thigh, which he attributed to playing volleyball and tennis in the past few days. He underwent another course of chiropractic treatments with the same intern and supervising clinicians, who provided the same treatment as before, once a week for four weeks. However, each treatment only offered temporary relief.

Two weeks later, the patient revisited the Clinic complaining of severe, constant pain in his right posterior thigh, with an intensity ranging from 2 to 8 out of 10. The pain in his thigh was affecting his ability to sit and walk for more than an hour. NSAIDs helped relieve his thigh pain. He mentioned that he still did not have any lumbar pain, but he reported a new symptom of intermittent electrical-like pain in his right testicle, especially when sitting for prolonged periods. Unfortunately, the new testicular symptom was not investigated.

During the physical examination, he was now limping on the right side and had difficulty extending his right knee due to posterior thigh pain. When asked about coughing, sneezing, and bearing down during bowel movement (Dejerine's triad), he reported experiencing pain in the right thigh. Valsalva's manoeuvre was negative. Neurological examination of the lower extremities did not reveal any weaknesses (5/5), and the deep patellar tendon reflexes were brisk but symmetrical at 4+, and the Achilles tendon reflexes were graded at 2+ bilaterally. Sensory examination of the lower extremities showed a slight decrease in light touch over the lateral aspect of the right foot (S1). Ankle clonus was absent and plantar responses were down-going. Straight leg raise was approximately 60 degrees bilaterally without nerve root tension signs. His treatment regimen remained the same as before, consisting of deep soft tissue therapy and SMT directed at the L4-L5 vertebral segment, which provided immediate relief of his posterior thigh pain.

He returned four days later reporting that his right posterior thigh pain had flared up again a couple of days after his last treatment. However, he mentioned that his right testicular pain had improved by 40%. He was able to lie down on his stomach and on his back without any discomfort. He was taking Naproxen® and cyclobenzaprine®, which he had recently been prescribed by his GP.

A few days later, his condition worsened. He still denied having any lumbar spinal pain. When standing upright, his right leg could not be raised passively (standing SLR) more than 30 degrees, causing severe right posterior thigh pain. He received electrotherapy (TENS) for the right leg, but no SMT to the lumbar spine. After the treatment, he reported no significant improvement. Radiographs of the lumbar spine were recommended to rule out a spondylolisthesis, but he chose to wait to discuss it with his GP.

He returned five days later, stating that his last treatment only provided temporary relief. Further investigation of his right hamstring and right sacroiliac joint was difficult as he was now experiencing too much posterior thigh pain to lie down in the prone position. Palpation of the lumbar spine was unremarkable for muscle spasms or local articular dysfunction. He was questioned regarding bowel and bladder functions, which the patient found strange and unrelated to his condition. He did, however, state that he had trouble emptying his bladder for the past three days. Repeated neurological examination remained unremarkable for pathological reflexes and motor power loss in the lower extremities. Deep tendon reflexes revealed a diminished right Achilles tendon reflex at 1+ versus 2+ on the left. There was a sensory deficit to a painful stimulus over the posterior right thigh. Valsalva's manoeuvre remained unremarkable. Other special manoeuv-

res, such as anal tone, cremasteric and bulbocavernosus reflexes, were not performed.

On that day, plain film radiographs of the lumbar spine were taken and reported by a radiologist. The report indicated joint space narrowing at L5-S1 and a small osteophyte posterior to L5-S1. The rest of the study was normal (Figures 1a, 1b).

Figure 1a.
Lumbar spine plain film radiograph (Anterior-Posterior view).

Despite not experiencing low back pain, the patient recently developed urinary retention and persistent right-sided leg symptoms, indicating a high risk of a lumbar disc herniation associated with early symptoms of CES. As a result, the patient was promptly referred for urgent care at the local hospital. Following an investigation, including an MRI of the lumbar spine, a large right paracentral disc herniation at L5-S1 was identified. This herniation compressed the right S1 nerve root, causing central canal stenosis and displacing the roots of the cauda equina towards the left (Figures 2a, 2b). Consequently, the patient was admitted on the same day and underwent a microdiscectomy at the L5-S1 level the following morning.

Figure 1b.
Lumbar spine plain film radiograph (lateral view).

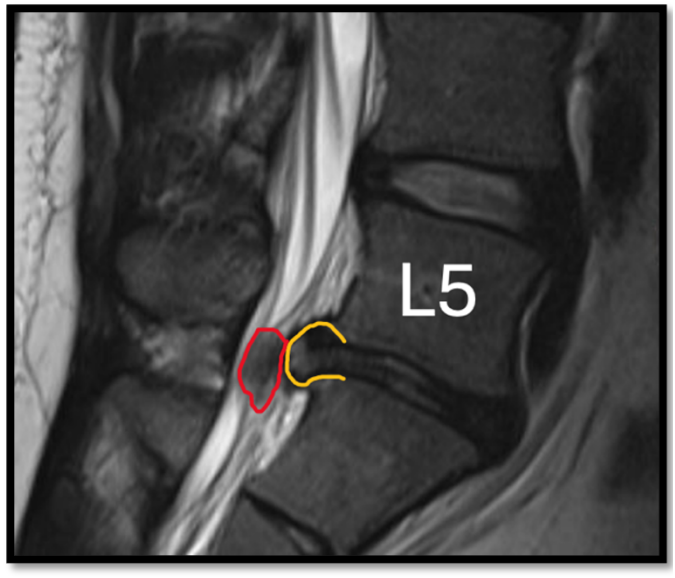

Figure 2a.
MRI T2-weighted sagittal view of L5-S1 disc herniation. In red, fragment of extruded disc.

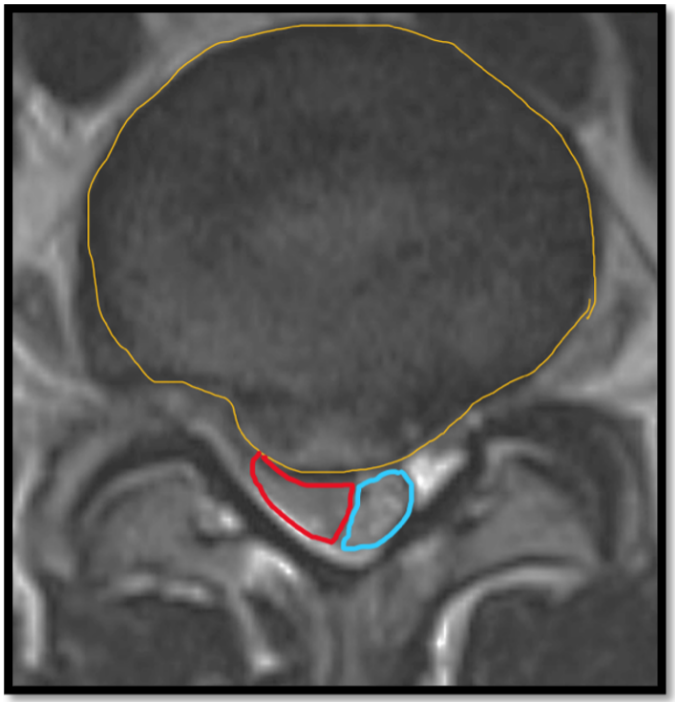

Figure 2b.
MRI T2-weighted axial view of the L5-S1 disc herniation resulting in central canal stenosis while displacing the roots (blue) of the cauda equina. In red fragment of extruded disc.

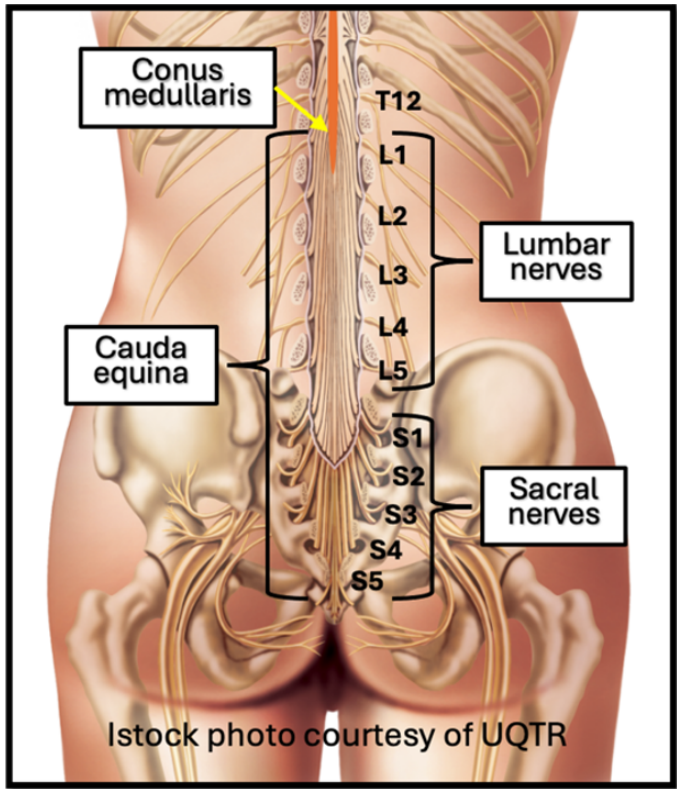

Figure 3.
Illustration of the cauda equina consisting of the lumbar and sacral nerves. Conus medullaris is located at the end of the spinal cord (Istock photo courtesy of UQTR).

Eight months after the surgery, the patient was doing well. His urinary function had fully recovered. Although the right posterior thigh pain had initially gone away after the surgery, it returned temporarily six weeks later when he tried jogging for 30 minutes. He has since switched to swimming and cycling. Apart from the persistent brisk patellar deep tendon reflexes (4+), the remaining neurological examination was normal, including symmetrical patellar reflexes at 4+ and Achilles tendon reflexes at 2+. Straight leg raise remained restricted to about 50 degrees bilaterally, but there were no nerve root tension signs. Overall, he was satisfied with the results of the surgery.

Discussion

The cauda equina is made up of all the lumbar and sacral nerves that emerge from the spinal cord and travel in the spinal canal below the level of the conus medullaris (Figure 3). When the conus medullaris is compressed at the level of the L1-L2 vertebral segment, it can cause clinical signs and symptoms similar to CES. In these cases, patients may have a combination of CES symptoms and concomitant compression of the conus medullaris.

The clinical conditions known as "cauda equina syndrome (CES) and conus medullaris syndrome (CMS)" are both rare and are often discussed together when it comes to their epidemiology. Depending on the site of compression, the clinical signs and symptoms can involve upper motor neurons, affecting the sacral segments only in the case of compression of the conus medullaris, and lower motor neurons when involving CES.

CES classification scheme: a clinical tool

CES can occur suddenly or over a long period. In both cases, individuals may experience severe back pain (83%) and radiculopathy (90%), along with sphincter and perineal symptoms, which are considered the hallmarks of CES.[6] According to Fuso *et al*.'s[7] epidemiological study,

there is a significant time delay ranging from two to 90 days (median time = 11 ± 24 days) between the onset of the symptoms and the final diagnosis of CES.

In acute CES, back pain increases severely and suddenly. There are sensory changes in a dermatomal distribution, as well as motor weakness and possible urinary retention, resulting in overflow incontinence and the need for catheterization. In chronic cases of CES, there is typically recurring and gradually increasing back pain with unilateral or bilateral sensory or motor loss. This is accompanied by gradual bowel and bladder dysfunction over several days to weeks.[1]

In a retrospective study of 32 CES cases, researchers aimed to identify potential reasons for the surgical treatment delays of CES. They found that misdiagnoses and lack of loss of bladder and bowel dysfunction were the most common factors.[8] The study also reported some physician-related factors, including CES not being considered, referral to an inappropriate specialty, inappropriate initial management, and inappropriate advice from the neurosurgical or orthopedic team. Additionally, the study stated that delays were more likely when fewer clinical features of CES were established at the time of presentation.

Consequently, to reduce delays in diagnosing CES, Lavy *et al*.[2] have recently proposed a comprehensive classification of five different levels of severity based on the presenting signs and symptoms of CES (Table 1). The first level, known as "suspected" cauda equina syndrome (CESS), involves subtle neurological presentations such as bilateral sciatica and motor or sensory loss in the legs, without bladder, bowel, genital, or perineal symptoms. The second level, "early" cauda equina syndrome (CESE), includes normal bladder and bowel functions with some changes in micturition frequency, as seen in our patient's symptoms. In cases of "intermittent" type of cauda equina syndrome (CESI), patients experience motor and sensory changes, such as saddle anesthesia, without having full retention or incontinence of the bowel or bladder. Instead, they may exhibit neurogenic visceral changes, such as using abdominal compression to assist in voiding, loss of urgency, and alteration of the urinary sensorium.[9]

Table 1.
Table of comprehensive classification of cauda equina syndrome from Lavy et al.[2]

Severity/Progression of CES	Category	Cauda Equina Syndrome (CES) SIGNS & SYMPTOMS
Suspected clinically or radiological (earliest scenario)	**CESS**	**CESS = Cauda Equina Syndrome Suspected** Clinical CESS: No bladder/bowel/genital/perineal symptoms, but bilateral sciatica or motor/sensory loss in legs. Radiological CESS: known large disc herniation on MRI.
Early	**CESE**	**CESE = Cauda Equina Syndrome Early** Normal bladder, bowel, and sexual function, but some sensory loss in perineum or change in micturition frequency.
Intermittent	**CESI**	**CESI = Cauda Equina Syndrome Intermittent** Alteration in bladder/urethral sensation or function, but maintenance of executive bladder control +/– perineal sensory changes, or sexual or bowel sensory or functional changes.
Retention	**CESR**	**CESR = Cauda Equina Syndrome Retention** As in CESI, but with painless bladder retention and overflow.
Complete (worst scenario)	**CESC**	**CESC = Cauda Equina Syndrome Complete** Insensate bladder with overflow incontinence, no perineal perianal or sexual sensation, no anal tone.

The last two types of CES are what most practitioners recognize as typical signs of CES: "retention" cauda equina syndrome (CESR) and "complete" cauda equina syndrome (CESC). In CESR, patients have developed true urinary retention. Due to the loss of the visceral neurological signal to the central nervous system, they may experience painless urinary retention and eventually overflow incontinence. They may also experience retention or incontinence of the bowel.[6] CESC is a complete full-blown sphincter dysfunction with overflow incontinence, no perineal, or sexual sensation or anal tone.

Clinical presentation of CES

The clinical evaluation begins with pertinent screening questions about changes in bladder functions, such as frequency of voiding, difficulty initiating a stream of urine, the ability to suppress the urge to void, presence or absence of urinary incontinence, and loss of bowel control. In addition, related questions cover any changes or loss of feeling in the perineal or genital region, as well as loss of erection or ejaculation in males.[4]

Patients can have a plethora of additional symptoms, and the results of the physical examination can vary greatly.[10] This can be due to differences between patients in the level of spinal compression, lateral shift of the cauda equina, and severity of nerve compression throughout the cauda equina, as well as the potential compression of the conus medullaris at the L1-L2 level. As a result, lower motor neuron signs are usually more prominent with CES, while upper motor neuron signs can be present when there is compression of the conus medullaris (Table 2).

This case report shows an atypical presentation of LDH, where the patient experienced gradual posterior thigh pain, without lumbar pain. As described by Dr. Erwin, a chiropractor and molecular scientist, the distortion or pressure on the annulus fibrosus by herniated fragments activates mechanoreceptors and nociceptors within the annulus and posterior longitudinal ligament. This activation can lead to reflexive muscular activity, causing muscle spasms and low back pain typically seen in LDH.[11] However, nearly 20% of CES[6] patients do not experience low back pain. Our patient did not have any low back pain, most likely due to initial dominant spinal compression of the ipsilateral S2 nerve root, which also corresponds with his reported onset of neuropathic electrical-like testicular pain (Figure 4). Neuropathic testicular pain is typically caused by a lesion in the nervous system, located away from the area affected by the pain, such as the central or peripheral nervous system.[12] Therefore, the emergence of testicular pain followed by bladder symptoms several weeks later strongly suggests the diagnosis of CES and requires prompt medical referral.

Table 2.
Adapted from Dawodu ST, Cauda Equina and Clonus Medullaris Syndromes, Medscape, Jun 14, 2018.[10]

	CONUS MEDULLARIS SYNDROME (Upper Motor Neuron Lesion)	**CAUDA EQUINA SYNDROME (Lower Motor Neuron Lesion)**
Onset	Sudden & bilateral leg symptoms	Gradual & unilateral leg symptoms
LBP	Acute	Less acute
Sciatica	Less severe	More severe
DTR	Increased	Decreased
Sensory	Saddle anesthesia is symmetrical. Loss of sensation in both legs.	Saddle anesthesia is unilateral. Loss of sensation in one leg.
Plantar response	Present	Absent
Sphincters	Early dysfunction	Late dysfunction

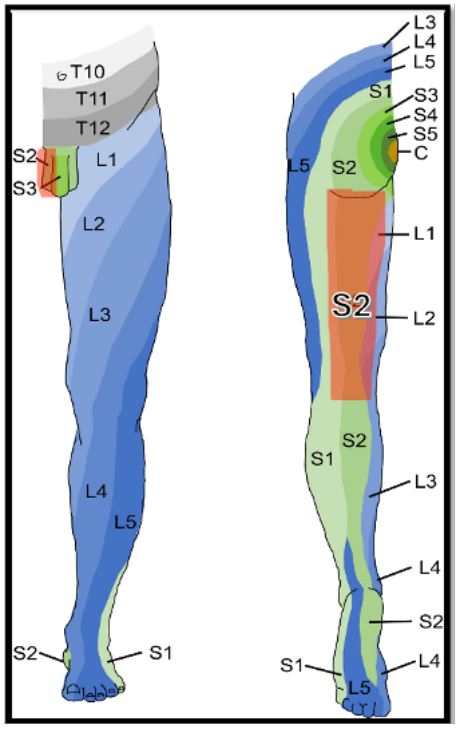

Figure 4.
Patient's areas of pain affecting the posterior thigh and testicle (orange). Adopted from Ostelo, R. W. Physiotherapy management of sciatica. J Physiother, 2020:66;83-88.[13]

Diagnostic evaluation of CES

The diagnosis of CES is often based on urinary dysfunction, as urinary excretion typically occurs more frequently than bowel excretion. However, a rectal evaluation may also show an absent rectal tone or an inability to voluntarily constrict, which further supports the diagnosis of CES.[6] Bladder studies can help identify urinary dysfunction in cases of CES, but their effectiveness as both diagnostic and prognostic tools has not been definitively established. Normally, values of more than 100 mL postvoid residual bladder volume should raise suspicion of urinary retention.[6]

Plain film radiographs are typically the initial imaging study for patients with spine-related complaints. However, they hold little value in evaluating patients suspected of having CES. MRI is the preferred imaging modality in such cases. If an MRI cannot be obtained promptly or if the patient's condition prohibits the use of magnetic resonance imaging (due to non-compatible hardware or claustrophobia), a CT scan should be performed instead.

Summary

Early symptoms and signs of CES can be challenging to diagnose. The presented case report highlights one of the many early presentations of the syndrome. When a patient presents with any leg symptoms, it is important to inquire about any changes in bowel and bladder function. In most cases of early cauda equina syndrome (CESE), there are subtle changes in urinary sensation, flow, and frequency before incontinence becomes apparent.[2] These changes should be taken as warning signs for CES. In this case, the patient reported feeling the need to urinate, but only a small amount or nothing would come out. Based on this relevant clinical symptom, it was important to refer the patient to the local hospital, which turned out to be the right medical decision. The patient received timely spinal surgical decompression, leading to a positive outcome.

The proposed comprehensive classification based on the severity of the presenting clinical signs and symptoms shows that CES is not simply an all-or-none clinical condition, but rather a continuum with variations in severity at onset and speed of progression.[2] The proposed classification of CES might help practitioners minimize the risk of misdiagnosing CES.

Additionally, practitioners need to recognize that patients with symptoms of CES may also exhibit signs of conus medullaris involvement, such as pathological reflexes. Regardless of where the spinal compression is located, CES is a serious condition that requires urgent surgical decompression to prevent permanent sphincter, motor, and sensory deficits.

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Conference Proceedings

Abstracts of the inaugural scientific poster presentation and award competition of the 2024 Royal College of Chiropractic Sports Sciences (Canada) Conference

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(JCCA. 2024;68(3):233-235)

KEY WORDS: sports, chiropractic, research

Introduction

The Annual RCCSS(C) Conference provides a venue for researchers, presenters, and attendees to advance sports healthcare practice, education, and research. The 2024 Annual RCCSS(C) Conference was convened on November 1st – 3rd, 2024 in Toronto, Canada. New to the 2024 conference was the Inaugural Scientific Poster Presentation and Award Competition. The RCCSS(C) Research and Education Committee would like to thank the Foundation for the RCCSS(C), individual donors to the poster awards, the RCCSS(C) Conference Committee, and all peer reviewers involved in judging the poster submissions for making the Inaugural Scientific Poster Presentation and Award Competition possible. Below are the abstracts of the poster presentations and award winners.

First Prize Poster

Quadriceps function and vertical hop performance in ACLR athletes: constraint dependent relationship

Nathan Boon, Walter Herzog, Matthew J Jordan.

Introduction: *Return of knee extensor (KE) capacity and plyometric function is crucial for athletes following anterior cruciate ligament reconstruction (ACLR). Repeat hop testing (RHT) is a common assessment for plyometric function, however the relationship between RHT performance and KE function requires exploration in ACLR athletes. External task constraints applied via verbal instructions influences the proportional contribution of the knee joint during RHT. Understanding this relationship may inform the utility of RHT in identifying knee function deficits in ACLR athletes. The purpose of this study was to compare the influence of two cueing conditions on single leg RHT performance and its relationship with KE function in injured and uninjured limbs of ACLR athletes.*

Methods: *Athletes 6–18 months post-ACLR (n=12) performed RHT (15 repetitions) under two cue conditions: 1) "hop as quickly as you can" (hop FAST) and 2) "hop as high and as quickly as you can" (hop HIGH). Jump height, contact time, and reactive strength index (RSI = jump height/contact time) were calculated. Isometric KE was evaluated at 90° flexion. Rate-of-torque development (RTD) was determined as torque at 100 ms following contraction onset.*

Results: *All variables were significantly different between the two cueing conditions for both limbs ($p<0.05$).*

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Jump height and RSI were significantly higher in the non-injured limb compared to the injured limb during the hop HIGH condition (p<0.05). KE torque and RTD independently explained a significant portion of variance in hop HIGH RSI (R2=0.19-0.45), but not hop FAST.

Discussion/Conclusion: *The two cueing conditions significantly modified RHT kinetics regardless of limb injury status. The hop HIGH condition illuminated significant inter-limb differences in RHT performance and moderate associations with KE torque and RTD not observed during hop FAST. Clinicians managing ACLR athletes may employ an RHT using the hop HIGH cue to specifically evaluate knee joint function.*

Second Prize Poster

The prevalence of sleep disturbance among competitive athletes presenting for care at the Sports and Exercise Research Collaborative for Health Practice-based Research Network (SERCH-PBRN)

Rachel Mochulla, Shailey Patel, David Oh, Alexander Lee, Brad Muir, Scott Howitt, Chris deGraauw, Lara deGraauw, Mohsen Kazemi, Glenn Cashman, Cameron Borody, Peter Stilwell, Kent Stuber, Katie de Luca, Sheilah Hogg-Johnson

Introduction: *Sleep disturbance influences athletic performance, recovery and training. Little is known about the prevalence of sleep disturbance among athletes. The Athlete Sleep Screening Questionnaire (ASSQ) is a validated questionnaire that assesses sleep quality, patterns, and disturbances among athletes and provides a sleep difficulty score.*

Methods: *Over a 6-week period, patients (athletes and non-athletes) aged 18+ who sought care from a SERCH-PBRN chiropractor were recruited to complete a survey about sleep. Only competitive athletes (varsity level and above) completed the ASSQ. The primary outcome was the sleep difficulty score (SDS), which is calculated from the ASSQ. Descriptive statistics were used to summarize patient demographic characteristics and the ASSQ SDS.*

Results: 1954 responses were collected from 25 clinics, with 179 completing the ASSQ. ASSQ respondents had a mean age of 36.3 years, with 35% being female. Of these respondents, 73% were categorized as having some level of sleep difficulty and 43% had moderate to severe sleep disturbance scores.

Discussion/Conclusion: *To our knowledge, this is the first study to deploy the ASSQ to measure sleep disturbance amongst competitive athletes in community-based sports clinics. With 43% of competitive athletes having a moderate to severe sleep disturbance score, sports chiropractors should be aware of the prevalence of sleep disturbance among the athletes they treat.*

Excellence Award Posters

A cross-sectional analysis of the Sport and Exercise Research Collaborative for Health Practice-Based Research Network (SERCH-PBRN) of Canadian chiropractors working in sport

Jonathan Okrainetz, Alexander Lee, Brad Muir, Scott Howitt, Chris deGraauw, Lara deGraauw, Mohsen Kazemi, Glenn Cashman, Cameron Borody, Peter Stillwell, Kent Stuber, Katie de Luca, Sheilah Hogg-Johnson

Introduction: *Practice-based research networks (PBRNs) provide the infrastructure to bring clinicians and researchers together to conduct research in real-life practice settings. PBRNs improve the generalizability of research, enhance recruitment capability, and facilitate quality improvement. The SERCH-PBRN was established to provide the Canadian sports chiropractic field with the framework to conduct practice-based research.*

Methods: *54 SERCH-PBRN chiropractors from 9 Canadian provinces were recruited to complete a cross-sectional, descriptive survey – the PBRN Clinician Questionnaire.*

Results: *51 SERCH-PBRN chiropractors completed the PBRN Clinician Questionnaire (94% response rate). Practitioner demographic, practice characteristics, and patient management highlights are reported in the provided tables and figures.*

Discussion/Conclusion: *To our knowledge, the SERCH-PBRN is the first sports chiropractic PBRN, providing a diverse, cross-country network of chiropractors working in sport. The SERCH-PBRN provides the sports chiropractic field with the infrastructure to conduct practice-based research.*

Experimentally induced central sensitization leads to echotextural changes in neurosegmentally linked skeletal muscle in healthy humans

Adam Wade, Scott Howitt, Jaclyn Kissel, Pawel Bartlewski, John Srbely

Introduction: *Musculoskeletal injuries are most prevalent in athletes in sports. Athletes are likely to develop myofascial trigger points (MTrP) at some point in their careers. Central sensitization (CSens) and Neurogenic Inflammation (NI) are believed to be the driving force behind MTrP formation. To date no research has been done in humans to investigate the relationship between central sensitization and echotextural changes within segmentally linked myotomes utilizing an algorithm to analyze pixel densities in B-mode ultrasound images.*

Methods: *A convenience sample of 14 healthy athletic participants aged 18-26 (10 female, 4 male) was collected. A single-blinded cross-over design was performed using an experimental (Zostrix – 0.075% capsaicin) sensitizing agent and a control (Lubriderm) non-sensitizing agent applied topically to the skin. Topicals experimental/control were applied from C1-7 and across the upper trapezius laterally to both AC joints as well as both lateral elbows in a 10x10cm area. Wind-Up ratio (WUR) was performed with a 256 mN PinPrick Stimulator (MRC Systems, Heidelberg, Germany) at baseline,10-,20-,30-minutes post intervention to validate CSens. B-mode ultrasound images were taken of the right biceps in transverse and longitudinal planes at baseline,10-,20-,30-minutes post intervention. A two-way repeated-measures ANOVA was performed to assess differences in echotexture and sum score (SS) with the novel algorithm, r-Algo.*

Results: *A significant negative correlation was shown between mean pixel intensity changes and pooled SS on all images taken in the transverse plane (r=-0.46, P=0.0003). Conversely, a positive correlation between mean pixel intensity changes and pooled SS was seen on images taken in the longitudinal plane (r=0.38, P=0.003).*

Discussion/Conclusion: *Transverse image findings support our hypothesis of mean echointensity reduction in relation to SS increase whereas longitudinal images showed a positive correlation between mean echointensity change and SS. This is the first study in humans to use an algorithm to correlate echotextural changes with CSens by assessing pixel densities from B-Mode ultrasound images. Ultrasound may be an effective tool for detecting NI and segmentally linked CSens. These findings may have important clinical implications in the diagnosis of myofascial pain. Future research with high resolution equipment and muscle biopsies to identify inflammatory markers and their echotextural range is needed.*

Neuroplastic training in a male soccer player following foot drop due to an iatrogenic cause: a case report

Sayyid Hassan, Katie Sheridan

Introduction: *Mirror therapy is a technique implemented by placing a mirror in the sagittal plane in between the limbs whereby, a patient performs an action and imagines regaining control over the affected limb. This case report highlights the treatment of a 46-year-old male who presented for chiropractic care following surgery to repair his right-sided knee ligamentous structures and a tibialis posterior tendon transfer following a collision during a soccer game. Following the initial surgery, there was a severe right-sided peroneal nerve palsy as the right peroneal nerve was severed during surgery. The patient was referred for care to increase ankle range of motion and for neuroplastic functional training of the new tendon transfer. The patient started chiropractic care eight weeks following the second surgery and presented for care twice to thrice weekly for 12 months. This care plan consisted of multimodal chiropractic care but specifically focused on mirror therapy.*

Methods: *The patient was treated with a combination of soft tissue therapy, acupuncture, active care, mobilizations, and mirror therapy over one year. Education and re-assurance were also included in the plan of management.*

Results: *In the 12-months following chiropractic care, the patient regained active dorsiflexion and was able to return to work (the patient worked as a factory line worker) and duties such as: being able to stand for four hours and walking and climbing stairs as tolerated.*

Discussion/Conclusion: *Iatrogenic peripheral nerve injuries (PNIs) are uncommon and routinely treated with surgery if there is no spontaneous resolution. Mirror therapy is commonly used to restore motor function in patients following a stroke. This case report suggests a potential use for mirror therapy in patients who have suffered an iatrogenic laceration of a peripheral nerve.*