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Contents

JCCA Vol 67 No 2 ISSN 00083194 (Print) and ISSN 1715-6181 (Online)

Original Articles

Editorial Board

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Physical activity counselling and exercise prescription practices of chiropractors in Canada and internationally: an exploratory survey

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Background: *Physical activity and exercise (PAE) counselling and exercise prescriptions increase patient physical activity. However, the perceptions/practices of chiropractors are poorly understood.*

Methods: *We surveyed the practices among chiropractors working in Canada (n=50) and Internationally (n=37). Chiropractors completed self-reflection questionnaires regarding their current practices and perceptions towards providing PAE counselling to patients. Chiropractor responses were obtained via Canadian provincial survey and educational workshops.*

Pratiques des chiropraticiens en matière de conseil en activité physique et de prescription d'exercices au Canada et à l'étranger: une enquête exploratoire

Contexte: *Les conseils en matière d'activité physique et d'exercice (APE) et les prescriptions d'exercices augmentent l'activité physique des patients. Cependant, les perceptions et les pratiques des chiropraticiens sont mal comprises.*

Méthodologie: *Nous avons enquêté sur les pratiques des chiropraticiens travaillant au Canada (n=50) et à l'étranger (n=37). Les chiropraticiens ont rempli des questionnaires d'auto-réflexion sur leurs pratiques actuelles et leurs perceptions quant à l'offre de conseils aux patients en matière d'APE. Les réponses des chiropraticiens ont* ***été*** *obtenues au moyen d'une enquête provinciale canadienne et des ateliers* ***éducatifs****.*

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JRF was, and SH is the Exercise is Medicine Canada National Advisory Council Chair. JRF was the Scientific Lead for Exercise is Medicine Nova Scotia. JRF received honoraria and travel to deliver Exercise is Medicine Canada workshops through an unrestricted grant from the Lawson Foundation. All authors made substantial contributions to conception and design, acquisition of data or analysis and interpretation of data; drafted or critically revised the manuscript; approved the final version.

Results: *Chiropractor respondents included PAE content and exercise prescriptions in most patient appointments (67±27% and 59±35%, respectively), but the largest barriers (2.5/4.0) and least confidence were in their patients to follow through (52±21%). Canadian respondents reported higher knowledge (~0.4/4.0 higher), greater self-confidence (10-20% higher), and provided more PAE recommendations (8%) and prescriptions (16%) than International respondents. Chiropractor respondents were least comfortable advising patients with cancer.*

Conclusion: *Chiropractor respondents may serve as health promotors to address patient inactivity, and the challenges identified should be addressed through educational training.*

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KEY WORDS: counseling; surveys and questionnaires; Canada; prescriptions; chiropractic

Résultats: *Les chiropraticiens interrogés ont inclus le contenu d'APE et les prescriptions d'exercices dans la plupart des rendez-vous avec les patients (67±27 % et 59±35 %, respectivement), mais les obstacles les plus importants (2,5/4,0) et la confiance la plus faible* ***étaient*** *à propos du fait que leurs patients allaient suivre les conseils (52±21 %). Les répondants canadiens ont fait* ***état*** *d'une meilleure connaissance (~0,4/4,0 de plus), d'une plus grande confiance en soi (10-20 % de plus) et ont fourni plus de recommandations (8 %) et de prescriptions (16 %) en matière d'APE que les répondants internationaux. Les chiropraticiens interrogés se sont montrés moins à l'aise pour conseiller les patients atteints de cancer.*

Conclusion: *Les chiropraticiens interrogés peuvent servir de promoteurs de la santé pour lutter contre l'inactivité des patients, et les difficultés relevées devraient* ***être*** *abordées dans le cadre d'une formation.*

(JCCA. 2023;67(2):105-116)

MOTS CLÉS : conseils; enquêtes et questionnaires; Canada; prescriptions; chiropratique

Introduction

The health benefits to engaging in regular physical activity and exercise (PAE) are well-established[1], but population rates of physical inactivity continue to be exceedingly high[2]. Healthcare providers serve an important role in helping promote PAE to patients. Patients who receive physical activity counselling or written exercise prescriptions increase their activity levels and therefore lower their risk of developing, or improve their management of, chronic disease.[3] Primary care providers (e.g., family physicians) are viewed as a useful source of PAE promotion.[4] However, they experience many promotional barriers (e.g., lack of confidence when discussing PAE) which contribute to their low rates of PAE counselling and exercise prescription.[4] Allied health professionals (e.g., chiropractors) may serve an important role in helping address patient inactivity, but the training, frequency, and experience levels of allied professionals integrating PAE into their patient appointments is not fully understood.

Chiropractic is a form of manual therapy that is commonly utilized to improve and/or maintain musculoskeletal function.[5] Chiropractors treat the musculoskeletal system to address the needs of their patients. This may entail discussing patients' physical activity patterns and recommending that they engage in or avoid specific exercises to aid in their treatment.[6] In students who attend Canadian Memorial Chiropractic College, 77% of respondents felt that exercise counselling is highly relevant to their intended specialty and 46% reported always counselling patients on exercise in their patient-provider interactions.[7] The level of confidence of practicing chiropractors in including PAE as part of a patient's plan of management and what barriers may prevent them from integrating PAE as part of regular care has not been previously established. Given their training in movement related practices and/or exercise science, practicing chiropractors may serve a useful role in promoting PAE to patients.

Globally, the accessibility, education and training, and scope of practice of the chiropractic profession varies country-to-country.[8] In the 90 countries surveyed, chiropractic education was offered in 48 institutions in 19 countries and legally recognized in 68 countries.[8] As reviewed

elsewhere,[8] Canada, United States, and Australia have a large proportion of chiropractors per capita. In comparison, Europe and Asia have a relatively low proportion of chiropractors.[8] Whether chiropractors in different countries and different cultures have similar perceptions and barriers to integrating PAE into their practice is unknown. Understanding the PAE practices of chiropractors is important for assessing health promotion practices and identifying areas of need for further education or training to equip more health professionals with the skills to help more patients lead physically active lifestyles.

The purpose of our study was to characterize the perceptions towards and practices of physical activity counselling and exercise prescription of chiropractors in Canada (Ontario and Nova Scotia) with those of an international group of chiropractors attending an Exercise is Medicine Workshop in Europe. We explored whether the confidence, practices and barriers experienced, differed between chiropractors working in Canada and Internationally.

Methods

Participants and recruitment

Chiropractors for the current study were recruited from three sources: one group online (Nova Scotia) and two groups in person (Ontario and International). Chiropractor perceptions and PAE practices were collected three ways: 1) Healthcare providers across Nova Scotia, Canada completed an online provincial wide questionnaire (FluidSurveys, Ottawa, ON), as part of an Exercise is Medicine Nova Scotia initiative led by the Nova Scotia Health Authority office of Research and Innovation and Acadia University. Only de-identified data from chiropractors working in Nova Scotia, Canada (year: 2017) were extracted from the provincial online questionnaire. Participants provided electronic consent for secondary use of anonymous group data analysis prior to completing the online anonymous questionnaire. 2) Chiropractors completed a hard-copy questionnaire prior to an Exercise is Medicine Canada Workshop in 2018 in Ontario, Canada; and 3) Chiropractors completed a hard-copy questionnaire prior to beginning an Exercise is Medicine Canada workshop at the 2019 World Federation of Chiropractic conference held in Berlin, Germany. The distribution of this survey was initially not for research purposes with country of origin of each respondent not being collected at this conference. All chiropractors respondents who attended these workshops or completed the provincial survey were included. The survey presenters (CD, SDH) anecdotally did not identify any Canadians participants who completed the survey, but this was not directly assessed. Similarly, it is not possible to discern the proportion of each World Federation conference attendee who works in Germany versus other countries and, therefore, we describe this group broadly as 'International'. All procedures were approved by the Acadia University (REB# 16-28) and Nova Scotia Health Authority (REB#: 1021602) Research Ethics Boards.

Perceptions and PAE practice questionnaire

Self-reflection questions were developed consistent with previous physical activity prescription questionnaires in healthcare.[4,9,10] Our questionnaire development and rationale for each domain is described in detail elsewhere.[4] We beta-tested the survey and the Exercise is Medicine Nova Scotia Steering Committee consisting of academic, healthcare providers, and decision makers edited and approved it. No personal information was required to complete the questionnaire. In brief, the self-reflection questionnaire included demographics (e.g., age, gender, ethnicity), PAE practice history, efficacy, barrier impact, and facilitator impact. Questions regarding demographic information, current PAE practice history, and barriers were developed from previous research in diabetes education.[11] The online and in-person questionnaires were nearly identical. The only difference in the questionnaires was that PAE practice history and efficacy variables were collected using visual analogue scales from 0-100% (1% increments) online but in 10% increments on the in-person questionnaire (i.e., 10%, 20%, etc.). Example questions are provided in Appendix 1.[12,13]

Self-efficacy, barriers, and facilitator questions

Multiple domains of self-efficacy (e.g., "*confidence in abilities to provide information, prescribe exercise*", "*confidence in abilities make appropriate referrals*", etc.) were quantified separately from other-efficacy (e.g., confidence in their patients' abilities to follow through on recommendations). Barrier and facilitator impact were collected using an ordinal scale (1-4); with lower values indicating a barrier or a facilitator that has a weak impact on their ability to provide PAE counselling (i.e., "*1 = does not prevent me from counselling*"). Conversely, a

higher barrier value indicates a very impactful barrier that prevents PAE practices (i.e., "*4 = completely prevents me from counselling*") and a higher facilitator value indicates the variable makes it very easy to complete PAE practices.

Knowledge, readiness, and comfort advising patients with chronic conditions

Knowledge to provide physical activity counselling, knowledge to prescribe exercise, and readiness to counsel patients on physical activity were assessed using an ordinal scale (e.g., "*not at all [0], slightly, moderately, very, extremely [4]")*. Difficulty including activity counselling in patient sessions was also assessed using an ordinal scale (i.e., "*not difficult [0], slightly difficult, somewhat difficult, difficult, very difficult [4]*").

Participants were provided a list of common disease conditions and were asked to identify those that they perceived as being "*most comfortable*", and "*least comfortable*", providing PAE advice. Disease conditions included cancer, cardiovascular disease, diabetes requiring insulin/secretagogue, diabetes not requiring insulin/secretagogue, hypertension, mental health, obesity, osteoarthritis, osteoporosis, other musculoskeletal conditions (e.g., low back pain), and respiratory diseases.

Data and statistical analysis

Respondents from the Nova Scotia online questionnaire and Ontario in-person workshop were combined into a single Canadian respondent group. Respondents who attended the Berlin in-person workshop were categorized into an International respondent group. All continuous variable distributions were tested for normality via the Shapiro-Wilk test. The only variable which met parametric assumptions was "*Confidence in Patients' to Achieve Exercise Recommendations*". Respondents' PAE practices and confidence in including PAE in appointments were compared between Canada and the International group via independent samples *t*-tests (parametric data) or Mann-Whitney U tests (non-parametric data). Physical activity counselling knowledge, prescription knowledge, difficulty in providing PAE counselling in patient sessions are presented as proportional data (%). The disease conditions for which chiropractors reported being most and least comfortable providing PAE advice, are presented as proportional data for each disease option (represented as a % of respondents). Data are presented as means ± standard deviation. Data were analyzed in SPSS (V28, IBM Statistics). The 95 percent confidence intervals (95% CI) were reported for all between-group comparisons and statistical significance was accepted as $p < 0.05$.

Results

A total of 87 licensed chiropractor respondents from Canada (*n*=50) and the International (*n*=37) chiropractic community completed a questionnaire of their PAE counselling and prescription behaviours. Table 1 displays the sample characteristics of the pooled results and between-group outcomes. Both groups of respondent samples were comprised of mostly experienced, middle-aged Caucasian chiropractors (Table 1). Most Canadian (58%) and International respondents (64%) saw >15 patients per day. Approximately half of Canadian respondents (48%) and International respondents (46%) saw patients for ≥20 minutes per session on average.

Table 1.
Comparing the self-reported characteristics and existing physical activity and exercise (PAE) training chiropractors by country.

Variable	Pooled (*n* = 87)	Canada (*n* = 50)	International (*n* = 37)	Mean difference [95% CI]
Age (years)	43 ± 12	42 ± 12	44 ± 12	-2 [-7, 3]
Gender (# men, # women, # did not disclose)	38, 41, 8	23, 22, 5	15, 19, 3	-
Ethnicity (% Caucasian)	92	92	92	-
Years of Practice	16 ± 11	15 ± 11	17 ± 11	-2 [-7, 3]
Average Number of Patients Seen (patients/day)	16-20	16-20	16-20	-
Average Length of Appointment (minutes)	21-30	11-20	21-30	-
Received Training in PAE (*n*=Yes, % Yes)	46 (55)	36 (75)	10 (29)	-

Note: *Pairwise comparisons between Canadian and International chiropractor respondents were conducted using Mann-Whitney U-tests for continuous variables and Chi-square testing for categorical variables. For continuous variables, the mean difference and 95% confidence intervals are reported. CI, confidence interval; PAE, physical activity & exercise. Data presented as means ± SD or proportions.*

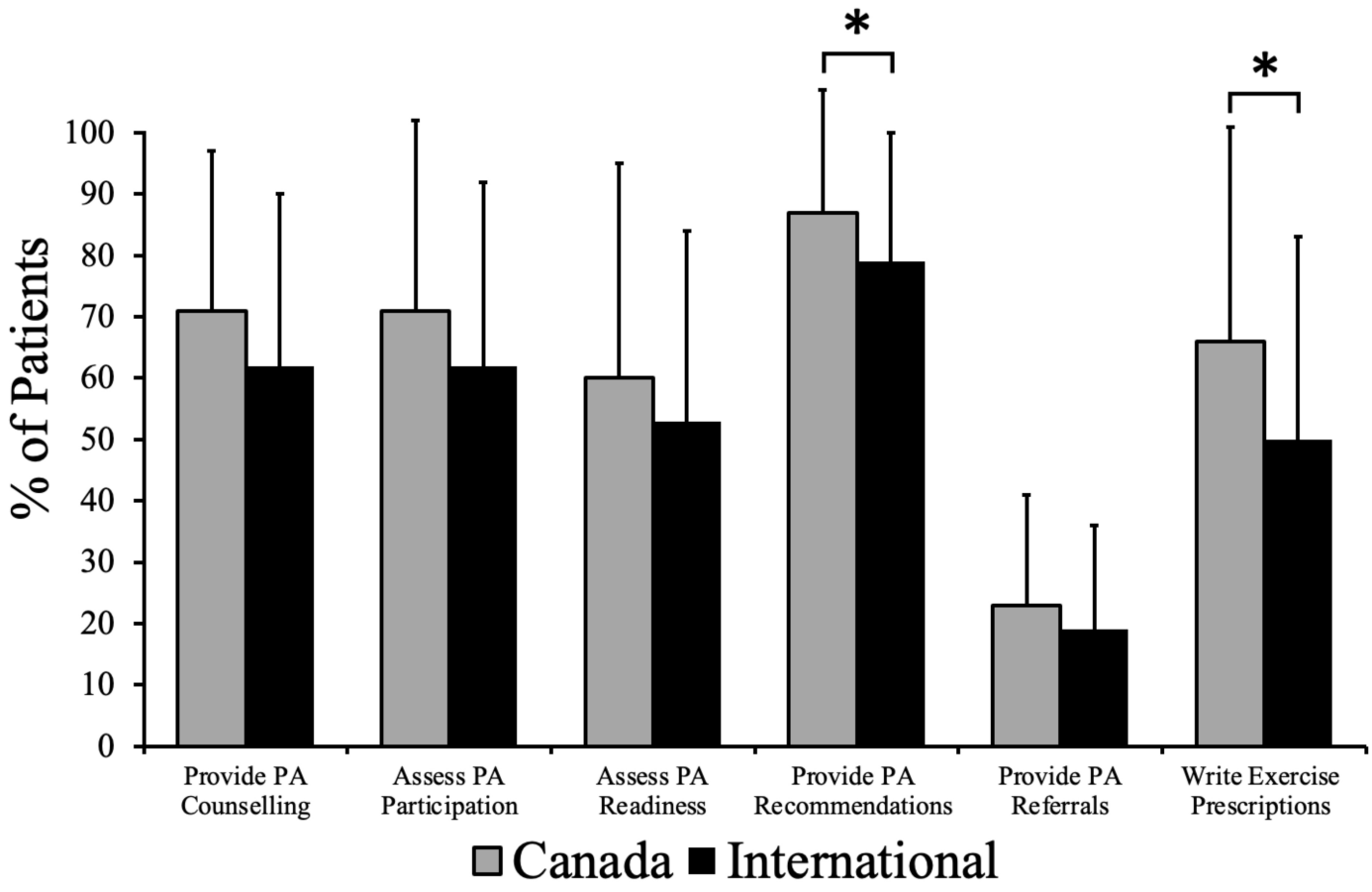

Figure 1.

The percentage of chiropractors providing physical activity and exercise (PAE) counselling, assessing PAE participation, assessing PAE readiness, providing PAE recommendations, providing PAE referrals, and writing exercise prescriptions to patients. Canadian versus International comparisons are based on Mann-Whitney U testing with a p-value significance level of p<0.05.

Proportion of physical activity counselling and exercise prescription

As shown in Figure 1, both groups of respondents demonstrated similar proportions of physical activity counselling (Canada: 71±26% vs. International: 62±28%, p=0.135, 95% CI: [-3, 21]), PAE participation assessments (71±31% vs. 62±30%, p=0.147, [-5, 22]), PAE readiness assessments (60±35% vs. 53±31%, p=0.405, [-9, 21]), and referrals to exercise professionals (23±18% vs. 19±17%, p=0.151, [-3, 11]). However, Canadian respondents reported higher proportions of providing PAE recommendations (87±20% vs. 79±21%, p=0.024, [0, 17]) and written exercise prescriptions (66±35% vs. 50±33%, p=0.018, [1, 31]) than International respondents (see Figure 1).

Chiropractor knowledge and readiness

Figure 2 demonstrates the distribution of chiropractic knowledge and readiness between Canadian and International respondents. Most Canadian respondents were very-to-extremely knowledgeable in physical activity counselling (61% of respondents; average: 2.80/4),

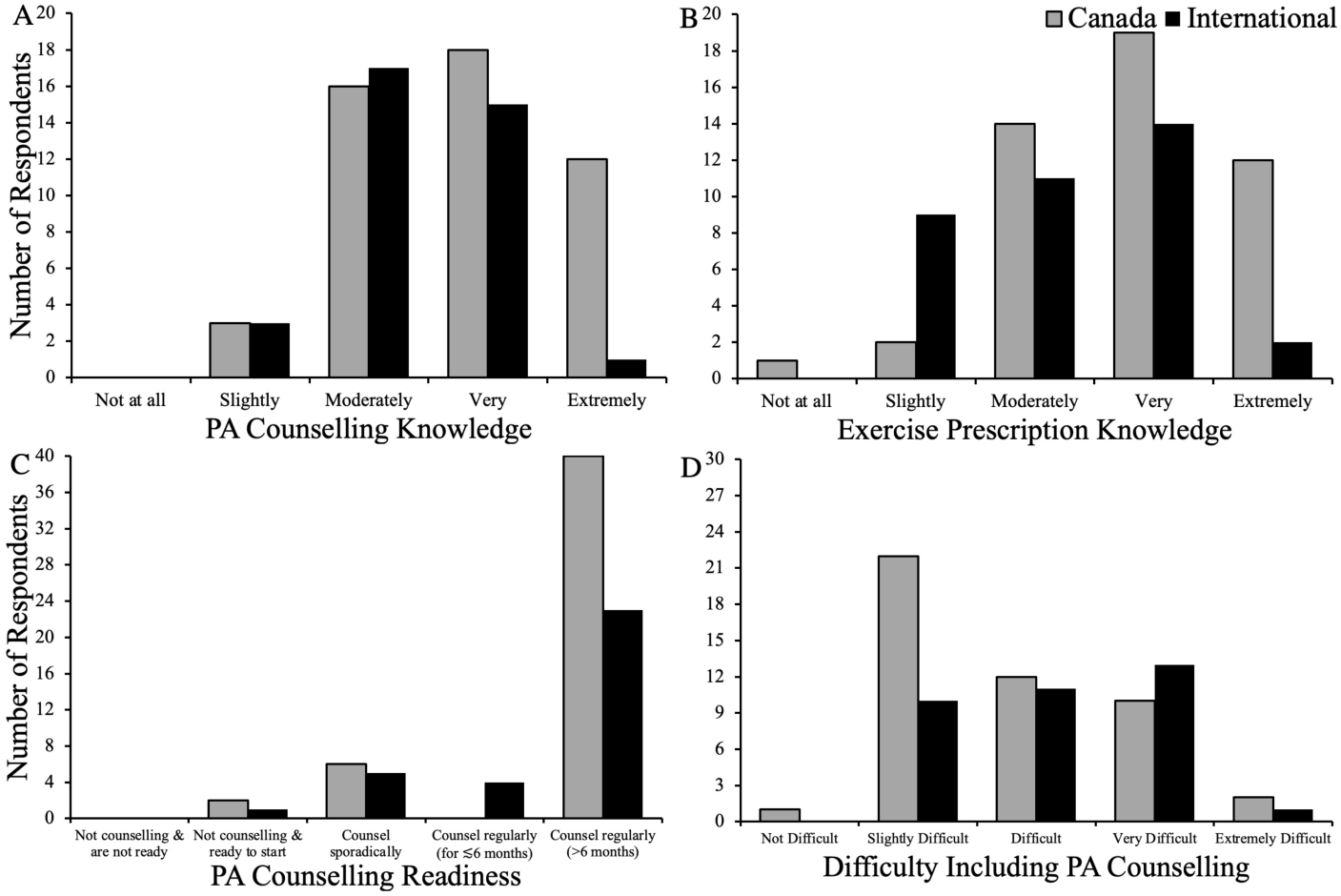

Figure 2.

The distribution of chiropractor physical activity (PA) knowledge (A) for prescribing exercise (B), readiness to include PAE counselling during sessions (C), and difficulty of including PA counselling during sessions (D). Canadian versus International comparisons are based on chi-square analysis with a p-value significance level of $p<0.05$.

which was higher than International respondents (44%; 2.39/4; Figure 2A). Similarly, most Canadian respondents were very-to-extremely knowledgeable in providing exercise prescriptions (65% of respondents; average: 2.83/4), which was higher than International respondents (44%; 2.25/4; Figure 2B). Both respondent groups were very-to-extremely ready to include PAE during sessions with patients (Canadian: 3.63/4, International: 3.48/4; Figure 2C) and found it slightly-to-somewhat difficult to include PAE counselling into sessions (Canadians: 1.79/4, International: 2.14/4; Figure 2D).

Confidence levels for providing PAE information to patients

Table 2 reports respondents' confidence levels for providing different aspects of PAE advice to patients. Canadian respondents were more confident in providing PAE information, assessing PAE readiness, answering PAE-related questions, maintaining PAE levels among patients, assessing PAE safety to begin PAE, advising patients with conditions, and providing PAE referrals (all $p<0.04$). Canadian and International chiropractors reported varying levels when asked about their confidence in patients to achieve PAE recommendations.

Table 2.
Self-reported level of confidence in providing physical activity and exercise (PAE) advice to patients.

Confidence in____ (out of 100%)	Pooled (*n* = 87)	Canada (*n* = 50)	International (*n* = 37)	Mean difference [95% CI]
Providing PAE Information	82 ± 17	87 ± 17	76 ± 15	11 [4, 18]*
Assessing PAE Readiness	63 ± 26	69 ± 27	54 ± 22	14 [4, 25]*
Answering PAE Questions	77 ± 21	84 ± 17	68 ± 22	16 [8, 24]*
Maintaining PAE in Patients	59 ± 25	64 ± 24	52 ± 25	12 [1, 22]*
Assessing Safety to Begin PAE	68 ± 24	73 ± 23	61 ± 23	12 [1, 21]*
Advising Patients with Conditions	57 ± 25	62 ± 24	50 ± 24	12 [1, 22]*
Providing Appropriate PAE Referrals	64 ± 28	73 ± 25	51 ± 28	22 [11, 34]*
Patients' to Achieve PAE Recommendations	52 ± 21	54 ± 22	50 ± 20	4 [-6, 13]

Note: *Pairwise comparisons between Canadian and International chiropractor respondents were conducted using Mann-Whitney U-tests. The mean difference and 95% confidence intervals are reported. CI, confidence interval; PAE, physical activity & exercise. *, indicates statistical significance of p<0.05 between Canadian and International respondents. Data presented as mean ± SD (%). For each variable, respondents rated their own confidence out of 100%.*

Table 3.
Self-reported level of comfort in providing physical activity and exercise (PAE) advice to patients with disease.

Chronic Disease	Highest Comfort Level		Lowest Comfort Level	
	Canada *n* (%)	International *n* (%)	Canada *n* (%)	International *n* (%)
Cancer	7 (14)	6 (16)	30 (60)	21 (57)
Cardiovascular Disease	17 (34)	15 (41)	21 (42)	10 (27)
Diabetes (Insulin/Secretagogue Required)	21 (42)	10 (27)	15 (30)	11 (30)
Diabetes (No Insulin/ Secretagogue Required)	26 (52)	14 (38)	5 (10)	2 (5)
Hypertension	21 (42)	15 (41)	7 (14)	3 (8)
Mental Health	23 (46)	11 (30)	10 (20)	6 (16)
Obesity	39 (78)	24 (65)	0 (0)	0 (0)
Osteoarthritis	45 (90)	22 (59)	3 (6)	0 (0)
Osteoporosis	30 (60)	21 (57)	9 (18)	3 (8)
Musculoskeletal (e.g., Low Back Pain)	48 (96)	30 (81)	1 (2)	1 (3)
Respiratory	9 (18)	5 (14)	26 (52)	12 (32)

Note: *Respondents were asked to select all diseases that they felt most/least comfortable providing PAE advice. CI, confidence interval; PAE, physical activity & exercise.*

Comfort levels for advising patients with disease

Table 3 includes respondents' comfort levels for discussing PAE with patients diagnosed with various chronic diseases. Both Canadian and International respondents were most comfortable providing PAE advice to patients with musculoskeletal conditions, osteoarthritis, and obesity. Both groups were least comfortable providing PAE advice to patients with cancer and respiratory conditions. While Canadians were less comfortable advising patients with cardiovascular conditions, International respondents were less comfortable advising patients with diabetes (insulin/secretagogue required).

Perceived importance of facilitators for prescribing exercise

Table 4 reports the perceived importance of facilitators for prescribing PAE to patients. Canadian and International respondents rated each potential facilitator for writing exercise prescriptions with varying levels of importance.

Perceived importance of barriers to prescribing exercise

Table 5 reports the perceived barriers to prescribing PAE to patients. Canadian and International respondents rated each potential barrier with varying levels of importance.

Table 4.

Perceived importance of facilitators that encourage physical activity counselling and exercise prescription.

PAE Counselling Facilitators	Pooled (*n* = 87)	Canada (*n* = 50)	International (*n* = 37)	Mean difference [95% CI]
Flexibility for Scheduling Patients	2.9 ± 0.9	3.0 ± 0.7	2.7 ± 1.1	0.3 [-0.1, 0.8]
Support from Co-workers//Manager/Organization	2.7 ± 0.9	2.8 ± 0.8	2.5 ± 1.2	0.3 [-0.4, 0.9]
Readily Available PAE Resources and Tools	3.1 ± 0.7	3.0 ± 0.7	3.2 ± 0.5	-0.2 [-0.6, 0.2]
Continuing Education Opportunities	2.5 ± 0.9	2.5 ± 0.8	2.6 ± 1.0	-0.1 [-0.7, 0.4]
Patient is Interested in PAE	3.3 ± 0.9	3.3 ± 0.9	3.3 ± 0.9	0.0 [-0.5, 0.5]
Self-Confidence in PAE Counselling	3.1 ± 0.9	3.2 ± 0.8	2.9 ± 1.1	0.3 [-0.2, 0.7]
Availability of Exercise Professionals for Referrals	2.9 ± 0.9	2.8 ± 1.0	3.0 ± 0.8	-0.2 [-0.7, 0.4]
Administrative Tools (i.e., PAE records, billing codes)	2.4 ± 1.1	2.3 ± 1.1	2.6 ± 1.2	-0.3 [-1.2, 0.6]
Patient is Ready to Engage in PAE	3.4 ± 0.7	3.5 ± 0.6	3.3 ± 0.8	0.2 [-0.2, 0.6]
Availability of Community PAE Programs	3.1 ± 0.7	3.1 ± 0.7	3.1 ± 0.6	0.0 [-0.4, 0.4]
Availability of Community PAE Facilities	3.2 ± 0.7	3.2 ± 0.7	3.1 ± 0.6	0.1 [-0.4, 0.4]

Note: *Respondents were asked to rank facilitators on a scale from 1 (not impactful) to 4 (very impactful). Data presented as mean ± SD. The mean difference and 95% confidence intervals are reported. CI, confidence interval; PAE, physical activity & exercise.*

Discussion

The primary objective of this exploratory cross-sectional study was to characterize the physical activity counselling and exercise prescription perceptions and PAE practices of chiropractors. Chiropractors included physical activity in most patient appointments, had moderate-to-high confidence in their ability to provide activity counselling, and cited patients' interest in PAE as their primary facilitator/barrier. Most PAE practices and barriers were not different between Canadian and International chiropractors, but Canadian chiropractors reported greater training, enhanced PAE knowledge, and higher confidence for physical activity counselling and provided more PAE recommendations and written prescriptions. Altogether, the results of this study document the knowledge, confidence and PAE practices that chiropractors have in promoting physical activity to patients and highlights areas of further improvement to inform continuing education or university education topics for Canadian and International chiropractors.

Table 5.
Perceived importance of barriers that prevent physical activity counselling and exercise prescription.

PAE Counselling Barriers	Pooled (*n* = 87)	Canada (*n* = 50)	International (*n* = 37)	Mean difference [95% CI]
Patient is Not Interested in PAE	2.5 ± 0.7	2.5 ± 0.7	2.6 ± 0.8	-0.1 [-0.5, 0.2]
Patient Prefers Medication Management	2.2 ± 0.7	2.1 ± 0.7	2.4 ± 0.8	-0.3 [-0.6, 0.1]
Lack of PAE Resources for Chronic Diseases	2.2 ± 0.8	2.1 ± 0.8	2.3 ± 0.7	-0.2 [-0.6, 0.3]
Lack of Time	2.1 ± 0.8	2.0 ± 0.6	2.4 ± 0.8	-0.4 [-0.8, 0.0]
Other Lifestyle Changes are More Important	1.8 ± 0.6	1.7 ± 0.6	2.1 ± 0.7	-0.4 [-0.7, 0.1]
Limited Personal Knowledge	1.6 ± 0.6	1.6 ± 0.6	1.7 ± 0.7	-0.1 [-0.5, 0.2]
Lack of PAE Education in School	1.6 ± 0.7	1.4 ± 0.6	1.9 ± 0.9	-0.5 [-0.8, -0.1]
Lack of Billing Structure for PAE	1.4 ± 0.7	1.4 ± 0.7	1.9 ± 0.9	-0.5 [-0.9, -0.1]
Lack of Evidence for the Effectiveness of PAE	1.3 ± 0.5	1.3 ± 0.5	1.2 ± 0.5	0.1 [-0.2, 0.4]

Note: *Respondents were asked to rank barriers on a scale from 1 (not impactful) to 4 (very impactful). Data presented as mean ± SD. The mean difference and 95% confidence intervals are reported. CI, confidence interval; PAE, physical activity & exercise.*

Providing patients with written exercise prescriptions is a proven means of increasing patients' physical activity levels.[3] The rates of prescriptions reported by chiropractors in the present study is higher than previous studies in physicians[9,12] and dietitians[14], but lower than to previous reports in a group of physiotherapists[18]. The rate of prescriptions appears to coincide with the availability of common facilitators like community programs and exercise facilities. Existing community programs should reach out to chiropractors (and *vice versa*) to ensure they are aware of existing programs and advocating for a greater development of these programs.[15] While the details of the exercise prescription that chiropractors typically provide patients with was not ascertained (e.g., aerobic, resistance, and/or balancing), it is hypothesized to be dependent upon the individual patient. Our study demonstrates that the self-reported high PAE knowledge, PAE confidence, exercise prescriptions and frequent contact with patients enables chiropractors to be valuable resources for promoting healthy lifestyle behaviours. Accordingly, the international problem of physical inactivity[2] cannot be addressed by a single type of healthcare provider, and patients will be more likely to engage in more physical activity if brought up and discussed by a range of health care providers, including their physician, dietitian, physiotherapist, chiropractor, etc.

The most impactful barrier to adding PAE content into patient appointments was patients not being interested in physical activity. This is similar to research we have conducted with other healthcare professionals.[4,14,18] Respondents also reported the lowest confidence in their patients' to achieve their PAE recommendations. Prior research has identified that chiropractors believe patients do not comply with home-based exercise recommendations due to a lack of patient time or forgetting to do the exercise.[17] These observations corroborate previous research highlighting the need for more behaviour change training to equip chiropractors with the necessary skills (e.g., goal setting, planning techniques, motivational interviewing) to address patients who are lower in their stage of change, improving their ability to promote healthy behaviours to all patients.[19,20] For instance, motivational interviewing and behaviour management are topics covered in the Exercise is Medicine Canada workshops for healthcare providers.[4] Providing chiropractors with more training opportunities should help to increase their PAE counselling confidence and reduce the impact of barriers such as lack of time or belief in patients.

The results of the current study also suggest that there is a need for better guidance on promoting exercise with some non-musculoskeletal conditions, such as cancer and respiratory disease, as respondents report low comfort on providing activity advice to these considerations. The patient-focused challenges and specific disease states of low comfort identified in our study provide direction for targeted interventions aimed at improving chiropractor's role as health promoters[6] and addressing international concerns of patient inactivity. Improving awareness and dissemination of disease-specific exercise recommendations (e.g., cancer guidelines)[21] would help address the low comfort level of these professionals.

Self-efficacy domains such as knowledge of PAE counselling, assessing PAE participation/readiness, providing PAE referrals (i.e., referrals to exercise professionals), and the facilitators of providing PAE counselling were not different between groups. Whereas other domains such as educational training in PAE, PAE counselling and exercise prescription knowledge, confidence in PAE counselling, and the rates of providing PAE recommendations and prescribing PAE tended to be lower in International respondents compared to the Canadian respondents. This provides useful information regarding the development of resources that can help build a chiropractor's confidence to conduct counselling, which in turn, will likely increase promotion and recommendations for prescribing PAE.[22] Short-term training interventions have documented effectiveness in improving healthcare providers' activity counselling confidence.[23–25] In addition, an evaluation of what health promotion content is covered in chiropractic training and available options for continuing education would help identify specific areas to integrate further training.

Strengths and limitations

This was not a hypothesis-driven study, and the purpose was to describe the PAE practices, confidence, barriers, facilitators, disease comfort level, physical activity counselling, and exercise prescription perceptions of a small, conveniently sampled group of chiropractors. We acknowledge that our findings are based on samples of chiropractors in Nova Scotia, Ontario, and attendees at an International conference held in Berlin, Germany, and that our results reflect the answers of our questionnaire respondents only and not of all chiropractors. Including two sources of Canadian chiropractors is a strength of the study. The International group did not presume to include any Canadians but a detailed background of where they worked was not available, and therefore it is unclear how homogenous this group was. Given that some respondents signed up for an Exercise is Medicine Canada workshop, it may be possible that those included in the present study are already "bought-in" on the importance of activity promotion, and potentially report higher PAE practices than their colleagues, although the reverse could also be true, that those with low knowledge and confidence may attend a workshop to improve these attributes.[10,23] Similarly, respondents may have responded in a way that is more socially desirable,[26] reporting more frequent PAE practices than they truly do, but objectively determining specific PAE practices was beyond the scope of this study.

Conclusion

The majority of chiropractors included in our study discussed PAE counselling and prescribed exercise in most patient appointments. However, we identified disease conditions (e.g., cancer and respiratory disease) and certain self-efficacy domains (e.g., confidence in activity counselling and frequency of providing recommendations and prescribing PAE) in which chiropractors were not comfortable with promoting PAE. A large-scale survey of chiropractor's rates of physical activity counselling and exercise prescriptions is warranted to further explore these potential areas for further evaluation. This study identified that chiropractors may need improvement in some areas to help patients lead more physically active lifestyles but also indicates that chiropractor respondents had the knowledge, confidence and PAE practices that may make them an under recognized source of PAE promotion.

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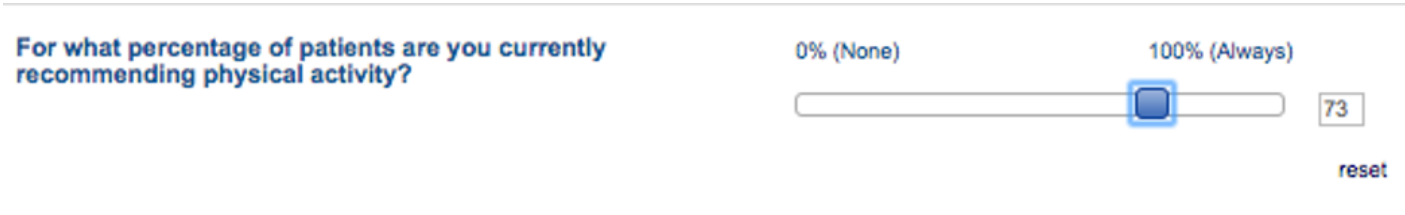
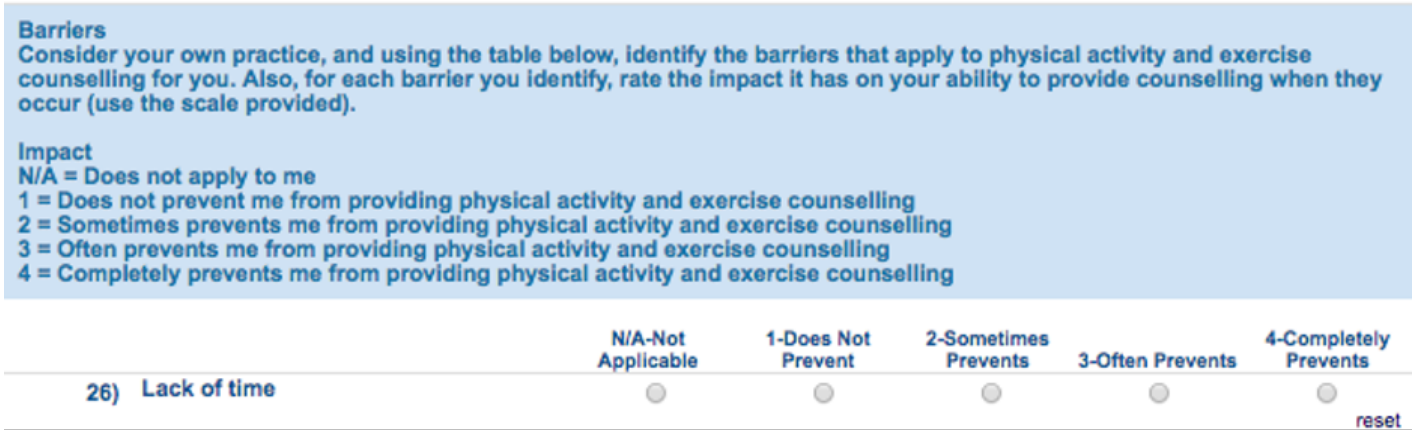
Appendix 1.
Example questions

A)



B)



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Relationship between backpack load location, sex, anthropometric and body composition factors with postural sway in healthy young adults

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Objective: *Evaluate the effect of backpack load location on postural sway and correlate sway path length (PL) to anthropometrics and body composition.*

Methods: *Fifteen participants aged 18-25 stood on a force plate with backpack load located high (LH), low (LL) or without backpack (NL). Body composition and anthropometric variables were correlated to PL.*

Results: *Load increased PL, 95% confidence ellipse, and mean velocity while it reduced mediolateral SampEn ($p<0.05$). Females had increased mean velocity and PL of sway ($p<0.05$). Larger phase angles correlated with reduced PL under NL. Taller individuals correlated with reduced PL under LL. Greater mass correlated with reduced PL under LH.*

Relation entre la position de la charge du sac à dos, le sexe, les facteurs anthropométriques et de composition corporelle et le balancement postural chez les jeunes adultes en bonne santé

Objectif: *Évaluer l'effet de la position de la charge du sac à dos sur le balancement postural et corréler la longueur du chemin du balancement (PL) aux facteurs anthropométriques et à la composition corporelle.*

Méthodologie: *Quinze participants âgés de 18 à 25 ans se sont tenus debout sur une plateforme biomécanique, la charge du sac à dos étant placée à un niveau élevé (LH), bas (LL) ou sans sac à dos (NL). La composition corporelle et les variables anthropométriques ont été corrélées à la PL.*

Résultats: *La charge a augmenté la PL, l'ellipse de confiance à 95 % et la vitesse moyenne tout en réduisant la SampEn (entropie d'échantillon) médio-latérale ($p<0,05$). Les femmes avaient une vitesse moyenne et une PL de balancement plus élevées ($p<0,05$). Les angles de phase plus importants sont en corrélation avec une réduction de la PL sous NL. Les personnes plus grandes étaient en corrélation avec une réduction de la PL sous LL. Une masse plus importante est en corrélation avec une réduction de la PL sous LH.*

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Ethics approval for this research was granted by the Miami University Office for the Advancement of Research and Scholarship (OARS) Institutional Review Board For Human Subjects Research (approval number 02066r).

DS and MW conceived the study. DS, MW designed, coordinated the study and drafted the manuscript. DS, MW were involved in the study-implementation, DS and MW performed the data analysis. DS, MW interpreted the findings. Both authors read and revised the manuscript critically and approved the final manuscript.

Conclusions: *Load carriage regardless of load location increased postural sway metrics except mediolateral SampEn. Females had greater PL and mean velocity compared to males. Select anthropometric and body composition variables correlated with postural sway under different load conditions.*

(JCCA. 2023;67(2):117-126)

KEY WORDS: posture, motor control, postural balance, backpack, body composition

Conclusions: *Le port de charge, quelle que soit la position de la charge, a augmenté les paramètres du balancement postural, à l'exception de la SampEn médio-latérale. Les femmes avaient une PL et une vitesse moyenne plus élevées que les hommes. Certaines variables anthropométriques et de composition corporelle sont en corrélation avec le balancement postural dans différentes conditions de charge.*

(JCCA. 2023;67(2):117-126)

MOTS CLÉS : posture, contrôle moteur, équilibre postural, sac à dos, composition corporelle

Introduction

Wearing a backpack induces a backward shift in one's center of mass (COM). This is compensated for by trunk forward lean in order to keep the COM vertically aligned over the pelvis to negate the posterior moment induced by the application of the load.[1] This finding is supported by numerous studies conducted involving both children and adults.[1] In addition to COM compensation, previous studies have found that carrying a loaded backpack increases postural instability (sway) as measured by center of pressure (COP) and has been suggested to induce greater balance impairment compared to no load.[1, 2] Interestingly, manipulation of load placement (high or low) in a backpack did not affect subjective and objective measures of postural stability in young adult participants[2] although the influence of sex was not specifically evaluated in this study.

While a loaded backpack seems to be consistently associated with greater postural sway and instability, the interaction of sex and backpack load on postural control appears to be less certain. Rugelj[3] did not find differences in postural response to the amount and configuration of load between male and female subjects using 12, 21 and 30 kg loads. Heller *et al*.[4] found that females carrying 18.1 kg of mass in a backpack experienced significant increase in COP sway but no males were assessed in their study. In a military study, overall load carriage injury risk for female and male soldiers were not different but female soldiers had twice the level of serious personal injuries as well as foot injuries, from carrying loads compared to male soldiers.[5] Findings from a recent systematic review regarding the impact of sex on postural stability were mixed[6], but that in two out of three studies, men tend toward better static postural stability compared to women. Clearly, the impact of sex with respect to load carriage and postural control is far from known and appears for the most part to have been largely neglected. Load will change the height of the center of mass of the 'human-backpack' system. It is reasonable that an increased distance between the center of mass and the ground would affect postural sway, as it would increase the moment of inertia around various points of rotation (ankles, hips etc). Since women and men have different distribution of mass in their upper and lower bodies, the effect of the load position may show differences in balance parameters between sexes.

Body composition is an important health and performance metric.[7] For instance, previous research of ours found that in young, elite hockey players, higher body fat percentage predicted slower skating speeds[8], which could be used to develop targeted and effective training programs to improve on-ice skating speed. Similarly, body composition may be able to predict postural sway with and without load carriage. Body composition as assessed by bioelectrical impedance analysis can be a reasonable alternative for balance evaluation in the elderly.[9] This would be important given clinical concerns such as falls in the elderly[9, 10] and the potential for instability in children carrying heavy backpacks[11]. We are interested in factors

that may be able to predict postural sway performance. To date, predictions of postural sway are sparse and we are aware of only one study that has related body composition as measured by bioelectric impedance analysis (BIA) to aspects of postural sway.[9] Phase angle, derived from BIA is a linear method of measuring the relationship between resistance and reactance in an electrical circuit and is an indicator of cell membrane health and integrity.[12, 13] This study by Bertolini and colleagues[9] used elderly men and women and found an inverse relationship between phase angle as measured by BIA and sway area, mediolateral sway velocity and one legged standing. Additionally, Bertolini and colleagues[9] suggested that resistance training could result in greater phase angle which is related to better health. Of note is that BIA is the only body composition technique that produces phase angle, which is correlated with the prognosis of various diseases.[7]

We aimed to investigate the following in healthy young adults: 1) if a load placed higher or lower in a backpack differentially influences postural sway compared to no load, particularly with respect to sex; 2) the relationship of anthropometric and body composition variables to postural sway. Hypotheses of the present study were: 1) load located higher in the backpack would create greater sway than load located lower in the backpack particularly for females compared with no load; 2) higher percent body fat and lower phase angle would be associated with greater sway.

Methods

Participants

Fifteen participants (8 males, 7 females) participated in this study. Subjects' age range was 19-23 (21.3 ± 1.2 years) (Mean±SD), body mass (76.1±17.0 kg), height (172.5±8.8 cm) participated in this study. Participants were recruited from undergraduate and graduate classes in the Department of Kinesiology, Nutrition and Health. The study protocol, all forms used and the informed consent documents were approved by the Human Subjects Institutional Review Board at Miami University. All participants read and voluntarily signed a written informed consent document and completed a health history questionnaire. Our inclusion criteria were undergraduate and graduate students at our institution. Participants were excluded if they were not able to stand without pain while wearing a weighted backpack for 30 seconds.

Design and procedure

Each participant came to the biomechanics laboratory once for a 20-minute session. Participants wore athletic shorts and a t-shirt during the test. Each participant completed 3 tasks: force plate assessment with or without backpack (with high and low load); and anthropometric and body composition analysis. These tasks are described below.

We used a mixed design with one between-subjects factor and one within-subjects factor consisting of sex and load condition respectively. The repeated measures nature of the study was used to control for the potential influence of individual differences on load carriage. Given the within-subjects design, the sample size was estimated based on similar studies involving load carriage on postural control.[10, 14, 15] Specifically, a large effect size has been noted for the influence of load on path length (AP and ML) in elderly individuals[10] and load on NeuroCom balance scores in young adults[15].

Force plate assessment of postural sway

We asked participants to perform three, 30 second standing trials on a Balance Tracking System force plate (BTrackS™ , San Diego, CA), with eyes open. Standing involved normal upright standing with feet approximately shoulder width apart and arms by their sides. Data were acquired through the Explore Balance software application (Balance Tracking Systems, version 2.0.4) at 100 Hz. Data was filtered using a second order, digital Butterworth low-pass filter (point by point) implemented with Labview code block with a cut-off frequency of 4 Hz. The first 10 points of the signal were removed to account for lag. The entropy calculation used the parameters m=2 (subseries length), r=0.2 (similarity tolerance) and N=3000 (data length). Sample entropy was derived from the center of pressure time-series data. Each participant stood for their first trial without a backpack (NL). The other two trials were performed in alternating order between subjects beginning with the load low (LL) in the backpack, then the load high (LH). The next participant began with the load high in the backpack then the load low and so on. This was for convenience as to not keep taking the load out of the backpack. The amount of rest between trials was based on participant fatigue and time needed to load the backpack. Participants were asked to step off of the force plate between trials. Loading and unloading the backpack

took a couple of minutes. Participants were regularly asked about fatigue and offered more rest if they were noticing fatigue. Since the protocol only required them to stand still 3 times for 30 seconds we did not consider fatigue to be a factor that would impact our results.

The type of backpack used for this study was an Osprey Aether 70 (mass 2.49 kg, volume 73 liters, dimensions in cm 85h x 40w x 34d). The load added to the backpack consisted of 18.1 kg in the form of weighted plates. We chose this load for its ecological validity as backpacking and military applications do not use relative loads. We divided the backpack into two compartments of upper, and lower using high-density foam. The low load location consisted of putting the weighted plates at the bottom of the backpack while the load high condition had the plates at the top of the backpack with the high-density foam beneath to ensure both stability and common load placement across participants. Consistent with Golriz *et al.*[2], weights were placed in the backpack as close to the spine as possible and distributed evenly across the right and left sides of the backpack. The position of the weights were consistent across the participants and placed by a single investigator (MW) who used the same location relative to the shoulders with the top of the backpack just beneath the occiput on all participants. The backpack had adjustable hip and shoulder straps and the standard fitting procedure was followed to adjust the backpack for each of the participants. Participants further adjusted backpack straps to their own body and comfort level for pragmatic purposes. Participants were instructed to look at an eye level visual target at a distance 1.5 meters in front of them (Figure 1).

Figure 1.
Experimental force plate setup. Participants wore a backpack while standing on a portable force plate that was 1.5 m from a wall with a visual target. The yellow oval and pink oval represent the load high and load low conditions respectively.

Outcome measures used in this study derived from the force plate included: path length (PL), 95% confidence ellipse (95% CE), mean velocity, anteroposterior sample entropy (AP SampEn) and mediolateral sample entropy (ML SampEn).

Anthropometric and body composition variables

Height was measured in centimeters (cm) using a laboratory stadiometer. The rest of the variables were measured using an InBody 770 Body Composition Analyzer (Cerritos, CA, USA) multi-frequency bioelectrical impedance (BIA) device. Participants stood on the BIA platform barefoot with the soles of their feet on the metal electrodes. Participants then grasped the handles of the InBody 770 with their thumb and fingers contacting the electrodes. They then stood still for approximately one minute while maintaining their elbows fully extended and their shoulders slightly flexed and abducted as instructed by the device.

Outcome measures used in this study derived from the stadiometer and InBody 770 BIA included: height (cm), mass (kg), phase angle, and percent body fat.

Data analysis

Statistical analyses for postural sway were computed using a mixed ANOVA with the within subjects factor (load) consisting of three levels (NL, LL, LH) and the between subjects factor being sex. In the event of a significant interaction, post hoc tests were performed using Bonferroni corrected pairwise comparisons. Shapiro-Wilk test was run as a test of normality for each postural (e.g., dependent) variable as a combination of the levels of the between- and within-subjects factors across NL, LL and LH conditions. For any data that violated the assumption of sphericity as assessed by Mauchly's test, the Greenhouse–Geisser correction was applied. All analyses were conducted using IBM SPSS Statistics for

Windows, Version 25.0 (IBM Corp., Armonk, NY, USA). Statistical significance was set at an alpha value of 0.05.

Body composition and anthropometric variables were related to the PL of postural sway using Pearson correlation coefficients and multiple linear regression. To quantify the strength and direction of the above bivariate relationships, Pearson correlation coefficients were calculated. Statistically significant correlations were observed with $p \leq 0.05$. Independence of residuals was assessed for each regression by a Durbin-Watson statistic. The assumption of normality was assessed by inspection of histograms of standardized residuals and by P-P plots. To establish correlates of anthropometric and body composition variables with PL, multiple regression analyses were conducted using stepwise forward selection.[8] Separate regression analyses were run for each of the load conditions. Our goal was to identify from a limited number of anthropometric and body composition variables the factor(s) that account for the greatest variance (i.e., R^2) in postural sway and therefore optimize the prediction of path length. At each step in the forward selection, a p value of ≤0.05 was the statistical significance criterion to enter variables. All analyses were conducted using SPSS version 25.0.

Results

Effect of load and sex on postural sway

Means and standard deviations of postural sway variables are provided in Table 1. There were no violations to the assumption of normality ($p > .05$) for any dependent measure. Mauchly's test of sphericity indicated that the assumption of sphericity was met for 95% confidence ellipse, and AP SampEn ($p>0.05$). Sphericity was not met for ML SampEn, mean velocity and path length ($p<0.05$), so we used the Greenhouse-Geisser correction to interpret the main effect of load and interactions for these variables.

Table 1.
Means and standard deviations of postural sway variables.

Variable	No Load (NL)		Load Low (LL)		Load High (LH)	
	Males	Females	Males	Females	Males	Females
Path Length	36.18 (3.77)	46.87 (4.36)	42.18 (7.48)	54.94 (11.22)	42.49 (3.66)	50.86 (4.40)
95% CE	0.79 (0.33)	1.16 (0.66)	1.89 (0.71)	3.21 (2.26)	1.89 (0.63)	2.33 (1.28)
Mean Velocity	1.21 (0.13)	1.56 (0.15)	1.41 (0.25)	1.83 (0.37)	1.42 (0.12)	1.70 (0.15)
AP SampEn	0.10 (0.04)	0.11 (.03)	0.09 (0.04)	0.10 (0.03)	0.08 (0.03)	0.10 (0.02)
ML SampEn	0.33 (0.15)	0.32 (0.12)	0.17 (0.03)	0.19 (0.07)	0.20 (0.05)	0.22 (0.12)

M (*SD*) values are listed for each condition. Path length is measured in centimeters (cm). 95% CE=95% Confidence Ellipse (cm2). Mean velocity is measured in cm/s. Sample entropy (SampEn) is measured in bits.

Table 2.
Summary of ANOVA results for postural sway variables.

	Path Length			95% CE			Mean Velocity			AP SampEn			ML SampEn		
Source	**F**	***p***	***ηp²***	**F**	***p***	***ηp²***	**F**	***p***	***ηp²***	**F**	***p***	***ηp²***	**F**	***p***	***ηp²***
Load	6.62	.014	.337	16.7	<.001	.563	6.58	.014	.336	1.11	.345	.079	13.3	.001	.506
Sex	20.6	.001	.614	2.11	.170	.139	20.5	.001	.612	1.47	.247	.102	.046	.833	.004
Load x Sex	.602	.493	.044	1.78	.189	.120	.574	.507	.042	.169	.846	.013	.330	.642	.025

Separate mixed ANOVAs were conducted for each variable (Path Length, 95% CE, Mean Velocity, AP SampEn, ML SampEn) with load as the within subjects factor and sex as the between subjects factor. No load by sex interactions were significant. Significant *p* values (<.05) are bolded. Greenhouse-Geisser corrections were applied to ML SampEn, Mean Velocity and Path Length.

Table 2 presents the results of the mixed ANOVA's for each postural variable. There was a main effect of load for

each postural variable except AP SampEn. Load increased PL, mean velocity and 95% confidence ellipse. Load reduced ML SampEn, yet had no effect on AP SampEn. There were no significant pairwise comparisons between LH and LL for any postural variable. The load effect was explained by significant differences between NL and LL as well as NL and LH for each postural variable except for AP SampEn.

A main effect of sex and assessment of pairwise comparisons indicated an increase in both PL and mean velocity of sway with each load condition (NL, LL and LH) for females relative to males. There was no load by sex interaction for any postural variable (Table 2).

Anthropometric and body composition related to sway PL

A matrix of intercorrelations, which presents the correlation coefficients for pairs of variables, is shown in Table 3. Not surprisingly, the path length variables at different loads were strongly related to each other. For instance, PL NL and PL LH were strongly correlated (r = 0.77), indicating that PL NL could account for approximately 59% of the variance in PL LH sway and vice versa. Both percent body fat and age had no significant correlations with any other variable. Phase angle, height and mass were significantly related to each variable except age and percent body fat.

Multiple regression was run to assess predictors[16] (height, age, mass, phase angle, percent body fat) of path length (PL) under each load condition (NL, LL, LH). There was independence of residuals, for each regression as assessed by a Durbin-Watson statistic of 1.45 (NL), 1.79 (LL) and 2.08 (LH). The assumption of normality was met, as assessed by inspection of histograms of standardized residuals as they appear to be approximately normally distributed with means approximating zero and standard deviations of 1. P-P (expected cumulative probability vs observed cumulative probability) plots for each regression demonstrated points that were closely aligned along the diagonal line confirming the assumption of normality.

The multiple regression analysis of PL NL yielded phase angle as the only significant variable, $F(1,13) = 30.78$, $p<0.001$. The multiple correlation coefficient was -0.84 with an adjusted R^2 of 0.70 indicating that conservatively, 70% of the variance in PL NL was explained by phase angle as measured by the InBody 770 BIA. For the regression analysis of the criterion variable PL LL, height was the only significant variable, $F(1,13) = 6.18$, $p = 0.027$. The multiple correlation coefficient was -0.57 with an adjusted R^2 of 0.32 indicating that conservatively, 32% of the variance in PL LL was explained by height. Similarly, the multiple regression analysis of PL LH yielded body mass as the only significant variable, $F(1,13) = 15.32$, $p =$

Table 3.
Bivariate correlations between path length, anthropometric and body composition variables.

	Path Length (cm) (NL)	***Path Length (cm) (LL)***	***Path Length (cm) (LH)***	***Height (cm)***	***Age (yrs)***	***Mass (kg)***	***Phase Angle***	***% Body Fat***
Path Length (cm) (NL)	1.00							
Path Length (cm) (LL)	0.57*	1.00						
Path Length (cm) (LH)	0.77**	0.68**	1.00					
Height (cm)	-0.77**	-0.57*	-0.73**	1.00				
Age (yrs)	-0.23	-0.40	-0.37	0.17	1.00			
Mass (kg)	-0.64**	-0.55*	-0.74**	0.74**	0.22	1.00		
Phase Angle	-0.84**	-0.54*	-0.65**	0.67**	0.31	0.71**	1.00	
% Body Fat	0.27	0.01	0.00	-0.36	-0.03	0.19	-0.21	1.00

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

0.002. The multiple correlation coefficient was -0.74 with an adjusted R^2 of 0.54 indicating that 54% of the variance in the PL LH was explained by the subject's mass. These significant variables (phase angle – PL NL; height – PL LL; and mass – PL LH) had correlations above 0.5 and are indicative of moderate to strong correlations. Scatterplots of these variables are shown in Figure 2.

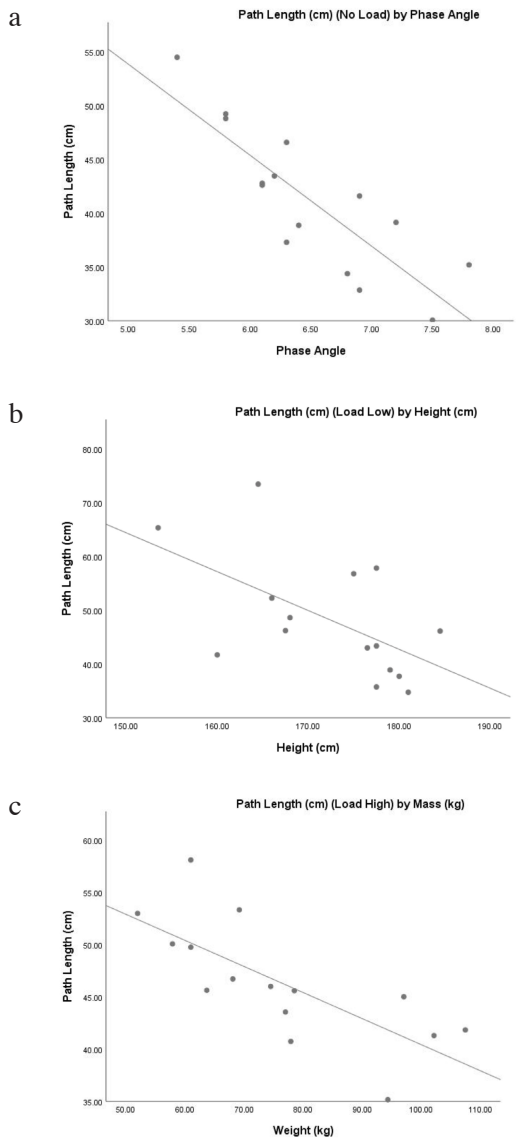

Figure 2. *Correlations between a) PL NL with phase angle, y=96.22-8.57(phase angle); b) PL LL with height, y=1.73E2-0.72(height); and c) PL LH with mass, y=65.44-0.25(mass).*

Discussion

Prior research has shown that backpack loads regardless of load location (high or low) increases postural sway metrics.[1] This could increase the potential for falls and instability in older as well as younger individuals.[9, 11] We confirmed that load (regardless of location in backpack) increased postural sway while reducing ML SampEn. SampEn, is a measure of movement structure and periodicity[17-20] and the observed decrease represents a greater amount of rhythmicity and structure of sway in the mediolateral direction with load. The reduction of SampEn may be associated with increased attentional demands to greater load bearing.[21-23] Our results contrast with those of Baudendistel *et al*.[24] who found that bimanual load carrying of 0%, 5%, and 10% of body mass resulted in greater AP SampEN with load but no change in ML SampEn. A different study examining bimanual load carrying of 0, 14, and 30 kg[23] found a reduction in both AP SampEn and ML SampEn particularly with the heaviest load. Despite the location of load in these two studies (bimanual)[23, 24] compared to our backpack study, collectively, greater loading appears to disrupt both the quantity and periodicity of sway.

We found that females swayed more than males in both PL and mean velocity of sway with each load condition relative to males. This is generally consistent with the systematic review by Dean *et al*.[6] at least under the condition of no load. We hypothesized that this increase in female sway would be magnified in the high load condition relative to males since loads placed more superior to the whole body center of mass lead to less effective postural control in parameters such as COP mean velocity.[25] However, since there was no load by sex interaction for any postural variable (Table 2) we cannot accept the hypothesis that load located higher in the backpack would create greater sway for females compared with males. Further, our results contrast to those of Rugelj and Sevsek[3] who did not find differences in postural response to the amount and configuration of load between male and female subjects using 12, 21 and 30 kg loads.

Our correlation analysis demonstrated that higher phase angle was significantly related to reduced path length of postural sway for each load condition which confirmed our hypothesis, but percent body fat was not related to sway as we hypothesized. Similar to percent body fat, age was not a related variable to PL of sway but it is noted that our sample consisted of a narrow age range. Height

and body mass were also significantly correlated to path length for each load condition and to each other.

Multiple linear regression found that phase angle was a significant correlate of PL of sway in the no load condition. This is consistent with Bertolini and colleagues[9] who found that higher phase angle in the elderly predicted reduced sway area and mediolateral sway velocity. The results from both of these studies might suggest a generalized inverse relationship across ages between phase angle as measured by BIA and postural sway variables making phase angle an attractive and possible alternate method to quickly assess posture control. Phase angle is an indicator of cell membrane integrity, distribution of intra- and extracellular fluids[9], and is associated with muscle quality[26]. Furthermore, phase angle has been demonstrated to increase following resistance training[27] indicating that this type of training may also relate to postural sway[28]. Height was a correlate of path length in the low load condition and body mass correlated path length in the high load condition. Previous research has found a difference in the correlation of postural measures with body factors such as height and weight. In women, postural sway (mean distance and mean velocity) magnified with height and weight.[29] Men however showed no significant change in sway size but significant reduction in sway frequency with height and weight.[29]

There are several limitations and/or ways to improve this study. An a priori calculated sample size estimate could have reduced the risk of an underpowered result or rejecting a null hypothesis that is actually true. We recognize that this limits the statistical power and that true differences between groups may not have been recognized as a result. The narrow age range of the participants precludes us from generalizing the findings to other populations such as middle-age and older adults. We could have used more than two locations for the load conditions as well as more than one magnitude of load to determine if gradations in these factors could have led to a sex by load interaction as we hypothesized. Another consideration would be to have a more dynamic postural task to determine if sex and/ or load in the dynamic situation leads to an interaction between load location and sway pattern. The duration of the postural sway trials might be considered a limitation given that measures of mean velocity for COP do not stabilize until trial duration is longer than 60 seconds[30] even though the premise for the original development of approximate entropy, of which sample entropy is a special case, was so that it could be used with shorter datasets[31]. SampEn was derived from the center of pressure time-series data and may be susceptible to long-range correlations which may mask underlying dynamics of the system.[32] An increment method to remove these long-range correlations has been proposed as a possible solution to these long-range correlations.[32] More variables from the BIA (body composition) might be considered as possible correlative variables in future studies as could other measures of anthropometrics. One potential issue however with this is that having too many variables for example from the BIA might lead to a multicollinearity problem.

Conclusion

Load carriage regardless of load location increased postural sway with the exception of mediolateral SampEn which reduced. Females had greater path length of sway and exhibited greater mean velocity of sway compared to males. Phase angle correlates with postural sway under no load while height correlates with sway while the load is located low in the backpack and body mass correlates with sway in the high load condition. Select anthropometric and body composition variables correlate with postural sway under different load conditions. The results of this investigation indicate that simple laboratory tests of select variables (phase angle, height, mass) could be used to aid in the assessment of postural stability in healthy young adults. This information could be valuable for monitoring and predicting postural performance in young adults who do not have access to a force plate. It may also provide health practitioners an opportunity to promote phase angle improvements to facilitate postural stability through means of resistance training, nutritional support or other lifestyle pursuits.

Abbreviations

ANOVA: Analysis of Variance
ML: Mediolateral
AP: Anteroposterior
PL: Path Length

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Understanding patient preferences for student clinician attire: a cross-sectional study of a student chiropractic clinic in Australia

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Objectives: *Previous studies have investigated the role of clinical attire in establishing patient-held perceptions of professionalism and knowledgeability across various healthcare settings. This study aimed to understand patients' preferences for chiropractic student attire.*

Methods: *Three hundred and twenty patients were recruited from a university chiropractic clinic and asked to complete an online questionnaire. The patients' preferences for five different attires were rated and*

Comprendre les préférences des patients en matière de tenue vestimentaire des étudiants en clinique: étude transversale d'une clinique chiropratique étudiante en Australie

Objectif : *Des études antérieures ont examiné le rôle de la tenue vestimentaire en clinique dans l'établissement des perceptions des patients quant au professionnalisme et à la compétence dans divers environnements de soins de santé. Cette étude visait à comprendre les préférences des patients en matière de tenue vestimentaire des étudiants en chiropratique.*

Méthodologie: *Trois cent vingt patients ont été recrutés dans une clinique chiropratique universitaire et invités à remplir un questionnaire en ligne. Les préférences des patients pour cinq tenues différentes ont*

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calculated as the composite score of five domains (knowledgeable, trustworthy, caring, professional, and comfortable).

Results: *While 71.9% of participants indicated that how students dress was important to them, most (63.4%) disagreed that wearing a white coat was essential for chiropractic student clinicians. The most preferred form of attire was the current clinic shirt.*

Conclusion: *The attire worn by chiropractic student clinicians at a single institution was found to be an influential attribute. Student chiropractic clinicians should dress professionally to make a good first impression. This study provided some guidance with the ongoing debate around students' dress code.*

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KEY WORDS: attire, chiropractic, dress code, student, teaching

été évaluées et calculées en tant que score composite de cinq domaines (bien informé, digne de confiance, attentionné, professionnel et confortable).

Résultats: *Si 71,9 % des participants ont indiqué que la tenue vestimentaire des étudiants était importante pour eux, la plupart (63,4 %) n'étaient pas d'accord avec le fait que le port d'une blouse blanche était essentiel pour les étudiants cliniciens en chiropratique. La tenue vestimentaire la plus appréciée était la chemise de clinique actuelle.*

Conclusion: *La tenue vestimentaire des étudiants cliniciens en chiropratique d'un même établissement s'est révélée être un attribut influent. Les étudiants en chiropratique doivent s'habiller de manière professionnelle pour faire une bonne première impression. Cette étude a permis d'éclairer le débat en cours sur le code vestimentaire des étudiants.*

(JCCA. 2023;67(2):127-141)

MOTS CLÉS : tenue vestimentaire, chiropratique, code vestimentaire, étudiant, enseignement

Introduction

In the healthcare environment, the first impression can be very important in building rapport with patients. The initial introduction forms the basis of the "Impression formation" theory, which involves the rapid evaluation of a person's character based on specific traits such as attraction, aggression, and how competent the person appears.[1] Evidence suggests that a patient's first impression substantially impacts how they perceive the practitioner and the success of future clinical interactions.[2] Furthermore, it has been established that such impressions are relatively stable and, once established, remain cemented over time.[3,4] The literature divides the factors contributing to a patient's perception of "professional attractiveness" into modifiable and non-modifiable categories.[5] Physicians' attire, in particular, can dramatically influence patients' perceptions of their healthcare professionals[2], explicitly dictating a sense of trustworthiness, knowledge, and expertise, which are all crucial traits for a clinician[6-9].

Evidence highlighting the importance of patient-centred care in clinical encounters is well-documented.[10,11] The modern healthcare landscape now largely conforms with Langberg's patient-centred triad, where the patient's condition, the doctor-patient partnership, and the coordination of care within a broader health system are privileged.[12] The concept of a patient-clinician relationship has been defined as the action of being respective and responsive to the preferences, needs and values of individual patients.[13] From its conception to the modern-day, the therapeutic benefit of providing emotional and cognitive care alongside physical care has been emphasised.[12] Attributed to increasing patient satisfaction and compliance, reduced healthcare costs, and improved patient outcomes, the patient-clinician relationship is an essential factor in every clinical encounter.[14] The quality of care and the patient-clinician relationship are core factors embedded into medical/healthcare professionalism.[15-17] Despite its multidimensional constructs[18], medical professionalism is linked to the delivery and implementation of healthcare, the implementation of trust within patients and the public, and the self-monitoring and ongoing improvement of medical/healthcare professionals[18,19].

Various studies have examined the influence of physician attire on patient experience[6,20-25], helping to establish

and strengthen this patient-clinician relationship. White coats have been reported as the preferred attire for medical students and medical physicians in the United Kingdom[26], Brazil[27], and the United States[28], with 85-90% of patients stating that they thought certain clinical attire was important for medical students[26]. In a Canadian physiotherapy[8] setting, there was a clear delineation between attire patients thought was professional (i.e. the white coat) and attire that patients preferred (tailored dress). Some studies investigated the effect of different aspects of clinician presentation on patients' comfort.[22] While there was no clear consensus on what the 'preferred clinician' should look like, some consistent qualities rated the highest level of patient discomfort, including wearing shorts, extravagant hair colour, long hair, and excessive jewellery such as multiple rings, facial piercings, and earrings.[27, 29]

There is limited evidence on patient perceptions of chiropractic professional attire and even more limited in a chiropractic student-clinician context. Although few web-based articles were published on how chiropractors should dress when practising, none explore the patient's perceptions and preferences of chiropractors' attire.[30] Connell and Bainbridge[31] examined how chiropractors build patients' trust through the use of semi-structured interviews. It was determined that trust was built through honesty, communication, perceived competence, and caring.[31] Although most interviewed chiropractors felt that their appearance, including professional attire, was required to build "perceived competence", the best attire was not explored.[31]

Patient preferences regarding chiropractic-student clinical attire have yet to be investigated. Therefore, this study aimed to answer the following research question: What are the patient's preferred chiropractic student clinician's attires? We hypothesised that students' attire influences patients' perceptions of students' knowledgeability, trustworthiness, and competence.

Methods

Study design, population, and sample size

We conducted a cross-sectional survey using an image-based online questionnaire depicting chiropractic student clinicians in varying attire for the patients to rate based on various qualities. Between March and October 2020, patients older than 18 without cognitive impairment who attended Murdoch University Chiropractic Clinic were invited to participate. We excluded chiropractic students attending the clinic as patients if they had completed more than the first two years of the program. This study was approved by the Murdoch University Ethics Committee (2019/083).

The sample size requirement was calculated using G*Power 3.0.10 and was based on a previous study[14] using a standard deviation of 2.2 with a mean difference of 0.3, assuming a 2-side alpha error of 0.05. The sample size was estimated at 305 participants to achieve 80% power.

Questionnaire development

With permission, the questionnaire was adapted from a previous study[14], and then piloted in 2019. The questionnaire was adapted from a cross-sectional observational study of 10 academic medical centres in the USA.[14] The questionnaire was modified to include photographs relevant to a student chiropractic clinic rather than medical centres. Questions related to different medical care settings were omitted as they were not applicable to a university-based chiropractic clinic. This questionnaire was then piloted within the Murdoch University Chiropractic Clinic in 2019 on 62 participants to determine its usability. Upon completion, it was recommended to duplicate section C (General Student Clinician Attire) for supervising clinicians. We found from the pilot study that the questionnaire was feasible and understood. Therefore, no other changes were made.

The survey questionnaires aimed to investigate how the following forms of attire influenced patients' perception: A) shorts and t-shirt with thongs (casual shorts), B) jeans and t-shirt with sports shoes (casual jeans), C) black dress pants and polo shirt with black shoes (polo shirt), D) black dress pants and white Murdoch University Chiropractic Clinic shirt with black shoes (clinic shirt), and E) black dress pants, black dress shirt (with a tie for male) and white coat with black shoes (whitecoat). The attire "D" is the current standard attire worn by students in the student clinic. Colour photographs of a male and female student clinician (wearing the different attire) were taken by a professional photographer (Figure 1). To avoid biases, the consistency of the facial expression, lighting, pose, and body language was maintained in all photographs. The male and female student chiropractic student models

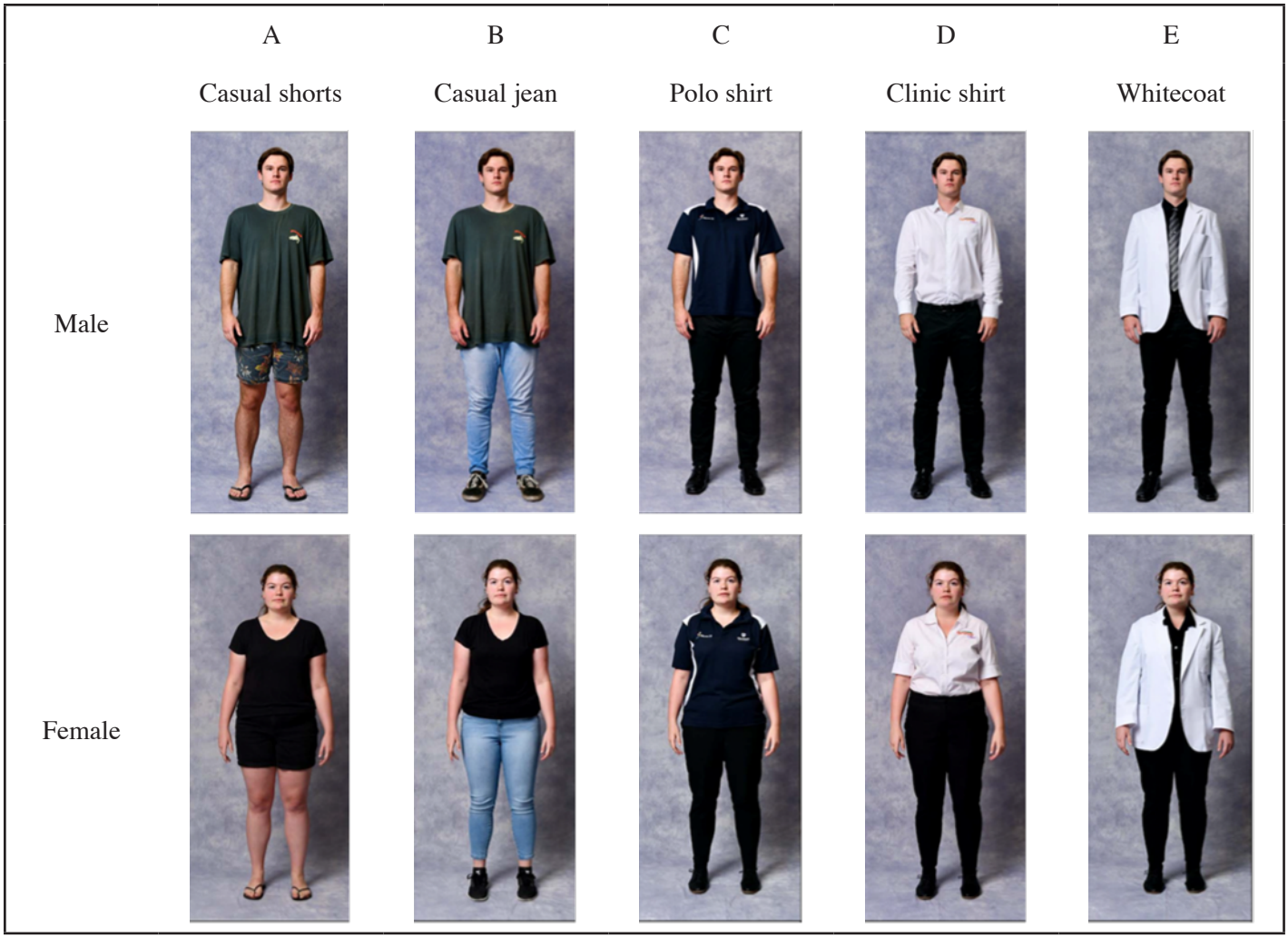

Figure 1.
Male and female attire photographs

were volunteer members of the research team providing written consent for the photographs to be used within the questionnaire and for publication.

Questionnaire description

Two questionnaires were used: a male and a female version. Questionnaires (Appendix 1) (male and female versions) each contained five sections and were administered through an electronic platform survey (Survey Monkey). The first section (Section A) had five questions for each of the five photographs asking participants to rate each image on a 10-point Likert scale (1: Somewhat to 10: Extremely) on how "Knowledgeable", "Trustworthy", "Caring", and "Professional" the student-clinician appeared and how "Comfortable" they felt. The following section (Section B) had the five photographs (male or female) and asked participants which image they preferred and to order images using a scale of 1 (prefer the most) to 5 (prefer the least). The photographs within Section A and Section B were presented to participants in a random order to prevent ordering or anchoring effects. This was achieved by using question randomisation through Survey Monkey (Momentive inc., San Mateo, California, USA).

The third section (Section C-1) included questions re-

lated to participants' general level of agreement on four statements: "1) How my student-clinician dress is important to me, 2) How my student-clinician dress influences how happy I am with the care I receive, 3) It is appropriate for a student clinician to dress casually when seeing patients over the weekend, and 4) Student-clinician should wear a white coat when seeing patients in the student's clinic. Participants rated these statements using a 6-point Likert scale (1: strongly disagree to 6: strongly agree). The fourth section (Section C-2) was similar to the previous one. However, the questions explored the participants' perception of supervisor clinicians' knowledgeability, trustworthiness, and professionalism in relation to how they dress. The questionnaire's final section (Section D) included demographic information regarding participants' age, gender, level of education, ethnicity, and how often they had attended the clinic.

Procedures

Before or after their appointment, participants were approached by a fourth-year chiropractic student and asked if they would agree to complete the survey, which took approximately 10 minutes. If interested, they were presented with an electronic tablet to access the survey, which included the study information, consent, and survey. Participants provided consent virtually before completing the questionnaire by clicking the "I agree button". Participants were not permitted to complete the survey twice.

To ensure a fair representation of patients attending the Murdoch University Chiropractic Clinic, a randomised list was created for each day of the week except Sunday. The list dictated, starting from the clinic's morning and afternoon opening hours, which patients were invited to complete the survey upon presenting to the clinic, and whether they would be assigned the male or female survey.

Statistical analysis

Data from the electronic questionnaires were downloaded and analysed using statistical software (IBM SPSS version 24, Armonk, NY). Descriptive statistics (means, percentage) and standard deviation (SD) were used to chart the results. Patient preference for the five different forms of attire was calculated as the composite score by calculating the average of five domains (knowledgeable, trustworthy, caring, professional, and comfortable) with a range of 1 to 10. Differences in the mean composite rating scores from the student-clinician rating section were assessed using a one-way analysis of variance. Differences in proportions for categorical data were compared using the $\chi 2$ test. Bivariate comparisons between male and female survey, participants' age, gender, and level of education and ethnicity with corresponding participant preferences for attire were assessed using $\chi 2$ tests with results reported as mean with 95% confidence interval (CI). A *p*-value (2-sided) ≤ 0.05 was regarded as statistically significant.

Results

Three hundred and thirty-one participants were invited to partake in this study, in which 320 (96.7%) completed surveys were returned and included in the analysis. Participants' demographic information is provided in Table 1. The mean age (standard deviation) of participants was 33.16 (13.59), 154 (48.1%) were female, and the majority were younger than 50 years (79.5%). A large percentage (38.9%) had completed a university undergraduate degree. Only 31 (9.7%) participants attended the clinic for the first time, while the remaining of them were almost equally distributed for attending the clinic between 2 to 3 times (30.9%), 4 to 8 times (24.7%), and more than eight times (34.7%).

The overall Cronbach's alpha for the five items included in the composite score was 0.91. The domain 'comfortable' was the domain with the lowest value considering the corrected item-total correlation. However, this score was still within the acceptable value and made no difference if this item was removed.

Image D (clinic shirt) was rated the highest (Table 2), with a mean composite score of 7.92 (1.41) and was regarded as the most preferred (Table 3). Image A (casual shorts) was the least preferred (Table 3) and was rated the lowest, with a mean composite score of 4.02 (1.94) (Table 2). As per the composite score, image D was statistically significantly higher than all other images ($p = 0.000$) (Table 2). Image "D" was also significantly higher in trustworthy and caring domains than all other images. Nonetheless, there was no significant difference in the knowledge and professional domains between image "D" and "E (whitecoat)" and in the comfortable domain between image "D" and "C (polo shirt)". The composite score of images A (casual shorts) and B (casual jeans)

Table 1.
Participant demographics

Characteristics	N (%)
Gender	n=320
Female	154 (48.1)
Male	160 (50.0)
Other	6 (1.9)
Age	n=331
≤ 25 years	126 (38.1)
26 to 50 years	137 (41.4)
> 50 years	68 (20.5)
Education	n=319
Less than high school	7 (2.2)
High school	87 (27.3)
Tafe	40 (12.5)
University undergraduate	124 (38.9)
University postgraduate	53 (16.6)
Decline to answer	8 (2.5)
Ethnicity	n=320
Australian	201 (62.8)
Indigenous Australian or Torres Strait Islander	2 (0.6)
New Zealander	8 (2.5)
Asian	58 (18.1)
European	29 (9.1)
Indian	7 (2.2)
Middle Eastern	1 (0.3)
African	5 (1.6
North American	1 (0.3)
South American	2 (0.6)
Decline to answer	6 (1.9)
Clinic visit	n=320
First time	31 (9.7)
2-3 times	99 (30.9)
4-8 times	79 (24.7)
More than 8 times	111 (34.7)

was statistically significantly lower than images C, D, and E. However, there was no statistical difference between images "A" and "B" (p = 0.435). Image "A" was also significantly lower in domains of knowledge, professional and comfortable than all other images, but there was no significant difference in the trustworthy and caring domains between image "A" and "B". Image "B" was also significantly lower in the domains of knowledge and professional than all other images. However, image "B" was not significantly different from image "E" in the comfortable domain.

There was no significant difference between the mean composite image score and the participants' age group. The composite score for image B (casual jeans) was statistically different between male (3.86; 95% CI: 3.55, 4.18) and female (4.48; 95% CI: 4.23, 4.74) surveys (p = 0.003). The composite score for images A (casual shorts) and B (casual jeans) was statistically different between participants' gender, with male participant rating image A (4.43; 95% CI: 4.11,4.75) and image B (4.61; 95% CI: 4.31,4.90) higher than female participants (Image A: 3.63; 95%CI: 3.36,3.91/Image B: 3.93; 95%CI: 3.66,4.19), (p = 0.001).

Specific differences in preferences regarding student attire established on participants' education level and ethnicity were also noticed. Considering the number of participants in each category, "Education" and "Ethnicity" were dichotomised to "High School or less" and "University" and "Australian" and "Non-Australian", respectively. Based on the composite score, images A, B, and D statistically differed between participants' education levels. University-educated participants rated images A (4.30; 95% CI:4.01,4.56) and B (4.47; 95% CI: 4.21,4.73) higher than participants without a university education (image A: 3.76; 95% CI: 3.42,4.08/image B: 4.05; 95% CI: 3.73,4.37) ($p < 0.044$). However, the rating contrasted for image D, where non-university-educated participants rated the attire higher (8.11; 95% CI: 7.88,8.34) ($p = 0.023$). Regarding ethnicity, images B, D and E's composite scores were statistically different between Australian and non-Australian participants, where non-Australian participants rated all images higher (image B: 4.53; 95% CI: 4.16,4.91/image D: 8.15; 95% CI: 7.89,8.41/Image E: 7.89; 95% CI: 7.59,8.20) ($p < 0.03$).

The majority of participants agreed or strongly agreed (71.9%) that how the student-clinician dressed was im-

Table 2.
Rating of student-clinician attire

Domains, mean (SD)	A	B	C	D	E
Knowledgeable	3.34 (2.22)	3.88 (2.04)	7.22 (1.63)	8.12 (1.52)	8.02 (2.00)
Trustworthy	3.87 (2.26)	4.17 (2.13)	7.26 (1.66)	8.04 (1.50)	7.42 (2.05)
Caring	3.99 (2.34)	4.22 (2.09)	7.21 (1.71)	7.83 (1.65)	6.92 (2.30)
Professional	2.38 (1.99)	3.07 (2.06)	7.47 (1.80)	8.42 (1.43)	8.27 (1.95)
Comfortable	6.51 (3.01)	5.90 (2.47)	7.47 (1.71)	7.17 (2.04)	5.91 (2.51)
COMPOSITE score	4.02 (1.94)	4.25 (1.81)	7.32 (1.53)	7.92 (1.41)	7.31 (1.82)

Table 3.
Preference for student clinician attire.

Preferences	N (%)
Preferred the most	n=320
A. Casual Shorts	17 (5.3)
B. Casual Jeans	13 (4.1)
C. Polo Shirt	113 (35.3)
D. Clinic Shirt	136 (42.5)
E. White coat	41 (12.8)
Preferred the least	n=62
A. Casual Shorts	223 (67.4)
B. Casual Jeans	36 (11.3)
C. Polo Shirt	10 (3.1)
D. Clinic Shirt	14 (4.4)
E. White coat	37 (11.6)

portant to them. However, most felt that wearing a white coat was not essential (63.4%) (Table 4). Almost 70% of participants strongly agreed or agreed that supervising chiropractor attire was important for them. Furthermore, most participants agreed that how the supervising chiropractor dressed reflected their perception of the supervising clinician based on knowledgeability (61.9% agreement), trustworthiness (62.8% agreement), and professionalism (75.3% agreement) (Table 5).

Table 4.
Participant's opinions on student-clinician attire.

	N (%)
1. How my student clinician dresses is important to me.	n=320
Strongly disagree or disagree	32 (10.0)
Neither agree nor disagree	58 (18.1)
Strongly agree or agree	230 (71.9)
2. How my student clinician dresses influence how happy I am with the care I receive	n=320
Strongly disagree or disagree	62 (19.4)
Neither agree nor disagree	109 (34.1)
Strongly agree or agree	149 (46.6)
3. It is appropriate for a student clinician to dress casually when seeing patients over the weekend.	n=320
Strongly disagree or disagree	100 (31.3)
Neither agree nor disagree	86 (26.9)
Strongly agree or agree	134 (41.9)
4. Student clinicians should wear a white coat when seeing patients in the student clinic.	n=320
Strongly disagree or disagree	203 (63.4)
Neither agree nor disagree	84 (26.3)
Strongly agree or agree	33 (10.3)

Table 5.
Participants' opinion on supervisor clinicians' attire.

	N (%)
How the supervising chiropractor dresses is important to me.	n=320
Strongly disagree or disagree	31 (9.7)
Neither agree nor disagree	66 (20.6)
Strongly agree or agree	223 (69.7)
How the supervising chiropractor dresses reflects how knowledgeable they appear.	n=320
Strongly disagree or disagree	36 (11.3)
Neither agree nor disagree	86 (26.6)
Strongly agree or agree	198 (61.9)
How the supervising chiropractor dresses reflects how trustworthy they appear.	n=320
Strongly disagree or disagree	34 (10.6)
Neither agree nor disagree	85 (26.6)
Strongly agree or agree	201 (62.8)
How the supervising chiropractor dresses reflects how professional they appear.	n=320
Strongly disagree or disagree	25 (7.8)
Neither agree nor disagree	54 (16.9)
Strongly agree or agree	241 (75.3)

Discussion

This study was the first to explore patients' preferences and perceptions of student-clinician attire in a chiropractic teaching clinic. In addition, this study also examined how participants perceived supervising clinicians' attire in terms of knowledge, trustworthiness, and professionalism. In both instances, approximately 70% of participants indicated that how students and supervising clinicians dressed was important to them. Participants believed the white coat was not essential for student clinicians to convey confidence or knowledge.

First impressions can potentially make a difference in how student clinicians are viewed; however, it is worth noting that the choice of dress may not correlate to clinical skills; a professionally dressed student may not have the best clinical skills, and a poorly dressed student may actually be an expert clinician. In building rapport with patients, many elements could come into play.

Unfortunately, comparing our results with the current literature is challenging as no other study has yet to explore the concept of chiropractic student attire. Troyanovich and Troyanovich[5], in 2015, published a historical perspective on physician attire and commented on the gap in the literature regarding patient preferences for chiropractors' attire. They asked a leading chiropractic trade journal to conduct an internet poll to explore how chiropractors dress. The poll was completed by 345 chiropractors and reported that almost 54% of chiropractors dressed in "smart casual" (polo-type/casual shirt with dress pants), with less than 13.6% wearing business attire with a white coat. This poll specifically addressed practising chiropractors, not students and did not address how the chiropractors' attire might impact their patients' perceptions.[5]

Only a handful of studies have been published regarding student attire and patients' perceptions of competence[26, 28, 32], all of which are regarding medical students. These studies used an image-based questionnaire and were conducted in the United States[28, 32] and the United Kingdom[26]. Two studies recruited participants in a hospital outpatient clinic (orthopaedic or otolaryngology)[26, 28] and one in a private surgical clinic.[32] In a specific clinical setting, Ahmed *et al*.[32] and Sax *et al*.[28] considered medical students perceived knowledge and professionalism based on their attire. Both studies reported that how medical students dress was important for patients, especially for men and older patients.[21, 28] Older participants reported being more comfortable when the provider wore a shirt and tie with a white coat rather than scrubs.[28] Similarly, Ahmed *et al*.[32] found that older patients perceived students in scrubs to be less knowledgeable, but the same results were not found in younger patients. Our results agree with the importance of students' attire as participants rate image D (clinic shirt) higher than all other attires. When wearing the clinic shirt, chiropractic students were perceived as being more trustworthy and caring compared to all other attires. Nonetheless, the white coat wasn't deemed a necessary tool to impart knowledgeability and professionalism, which is contrary to medical students.[26-28, 32, 33] Unfortunately, older participants were underrepresented in our study, and it was not possible to assess the effect of age on the importance of the white coat as reported in previous studies.[28, 32]

When examining studies conducted in mental health

care settings[34-36] or with physiotherapists[8] our results are comparable. This similarity with patient perceptions of the inappropriateness of the white coat could relate to the longer patient-physician relationship, as patients are often managed for a more extended period. In studies that have examined the physician's attire perceptions in the mental health field, only half of the respondents felt that psychiatrist attire was essential in establishing rapport.[9, 35-37] With respondents who thought that it was necessary, less formal attire was preferred.[37] Nome-Eikhom *et al*.[35] delved deeper into the reasoning behind this preference for less formal attire for psychiatrists. The authors concluded that psychiatrists wearing white coats seemed more competent but less understanding and approachable. Therefore, discarding the white coat was deemed to maximise the therapeutic alliance and increase approachability between psychiatrists and patients.[37] Similarly, chiropractic students often manage patients for a longer period, and as students must find their own patients, they often rely on close friends and family. Therefore, the white coat may not bear the same value of knowledgeability and competence as medical students.

Regarding physiotherapists, studies results are controversial regarding the white coat. While studies agree that business attire, as the preferred outfit, conveys confidence, knowledge, and comfort, the white coat was not viewed by all participants as an essential garment, especially if patients attended the clinic for a more extended period.[8, 38, 39] When asked whether wearing jeans was appropriate for physiotherapists, patients with greater than 50 visits felt that it wasn't inappropriate.[8] This differed with medical practitioners[14, 40], including medical students[26, 27], where more formal attire was preferred, increasing trust and confidence. Like psychiatrists and, in certain instances with physiotherapists, chiropractors tend to establish a more long-term doctor-patient relationship, which may decrease the perceived value of the attire. Our results also align with these findings as participants regard chiropractic students' attire as important. Yet, they don't perceive wearing a white coat as an added value to impart more confidence or knowledge.

Our findings differ from Petrilli *et al*.[14] who reported that college degree participants preferred more formal attire and a white coat. This divergence could be attributed to our greater proportion of students attending the clinic rather than to the level of education on its own. In addition, student participants may be more inclined to consider chiropractic interns as students instead of health practitioners.

Similar to our findings, where non-Australian participants preferred a more formal attire and a white coat, other studies also reported sociocultural differences.[14, 41, 42] Bramstedt *et al*.[41] examined the United States and Australian medical students and instructors concerning clinical professional attire41 and stated that white coats and neckties were nearly absent in Australian clinical attire.

Although our study did not address what attire supervising clinicians should wear, patients agreed that how the supervising chiropractors dress reflects how knowledgeable, trustworthy, and professional they appear. This finding was reported in other studies where medical practitioners' attire was correlated with the patient's perceptions of professionalism and competence.[6, 7, 14, 20, 21, 43-45] Jabbal *et al*.[26] also mentioned that it was important for patients to distinguish students from clinicians. Therefore, dressing appropriately may help patients with this process.

Strengths and limitations

Our study is the first to assess chiropractic student attire in a teaching environment using predefined photographs. Participants were randomly selected, decreasing the risk of selection biases, preventing an entire family from participating, and providing better representativeness of patients attending the clinic. The photographs were taken by a professional photographer, and we were attentive, ensuring that the models' facial expressions and postures were similar in all images.

Nonetheless, our study has some limitations that should be noted. First, as final-year students are asked to source their patients, many patients attending the chiropractic clinic are friends or family. This pre-established relationship may have biased how patients perceive their student-clinician favouring a more neutral or positive perception of trustworthiness, professionalism, and knowledge. This would also be true for participants who attended the clinic many times where a relationship had already been established. Both situations might have diminished the importance of the student attire. Secondly, our results must be interpreted cautiously as participants were recruited from only one centre within a teaching clinic. Therefore, results should not be extrapolated to

other chiropractic teaching clinics and regular practices. Finally, although we had multiple ethnicities, most participants were Australian, so results may not hold true across different cultures.

Future research

Our study took place in only one chiropractic teaching clinic. It would be valuable to examine other chiropractic teaching institutions in different Australian states and different countries to enhance our understanding of this concept and verify if patients' perceptions of student-clinician attire are similar where culture, language, and customs differ.

Conclusion

Based on a single institution, this study emphasises the influence of chiropractic students' and clinicians' attire and how vital it is for patients to establish the first impression to enhance patient-centred care. Trustworthiness and caring are important attributes that patients ascribed to student attire, while inappropriate attire decreases participants' perception of knowledgeability and competence. This study also guides the ongoing debate around students' and clinicians' dress codes and may help institutions better determine which proper attire is best indicated while attending clinical teaching placements. Overall, chiropractic students should dress professionally, but a white coat is not perceived as essential.

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Appendix 1. Questionnaire

Thank you for taking the time to complete this survey. Your answers will help us better understand whether student clinician chiropractors' dress influences patients' opinions of them.

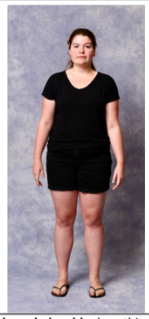
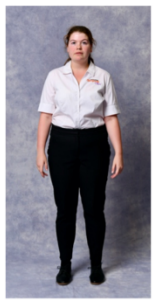
Your responses are important to us. There are no right or wrong answers, and we are interested only in your honest opinions. This survey is brief and should take no more than 10 minutes to complete.

In Sections A and B, please provide a rating by circling the number on the scale that corresponds to your answer. In Sections C and D, please provide your best answer to each question.

All of your answers will be kept confidential. We will not use names in any notes, reports, or summaries. Your responses will also not be shared with any of your care providers.

Section A– Student Clinician Attire – Rating

Please rate the student clinician for each of the following questions by circling the number corresponding to the answer

A	B	C	D	E
				
1. How **knowledgeable** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely	1. How **knowledgeable** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely	1. How **knowledgeable** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely	1. How **knowledgeable** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely	1. How **knowledgeable** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely
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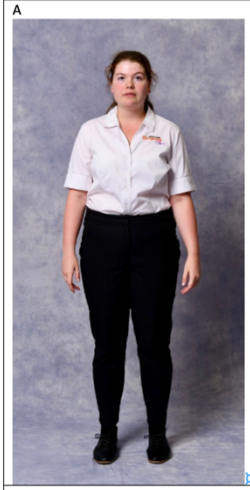
3. How **caring** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely	3. How **caring** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely	3. How **caring** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely	3. How **caring** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely	3. How **caring** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely
4. How **professional** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely	4. How **professional** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely	4. How **professional** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely	4. How **professional** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely	4. How **professional** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely
5. How **comfortable** does this student clinician make you feel? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely	5. How **comfortable** does this student clinician make you feel? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely	5. How **comfortable** does this student clinician make you feel? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely	5. How **comfortable** does this student clinician make you feel? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely	5. How **comfortable** does this student clinician make you feel? 1 2 3 4 5 6 7 8 9 10 Somewhat ····· Extremely

Please rate the student clinician for each of the following questions by circling the number corresponding to the answer				
A 	B 	C 	D 	E 
1. How **knowledgeable** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	1. How **knowledgeable** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	1. How **knowledgeable** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	1. How **knowledgeable** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	1. How **knowledgeable** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely
2. How **trustworthy** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	2. How **trustworthy** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	2. How **trustworthy** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	2. How **trustworthy** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	2. How **trustworthy** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely
3. How **caring** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	3. How **caring** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	3. How **caring** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	3. How **caring** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	3. How **caring** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely
4. How **professional** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	4. How **professional** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	4. How **professional** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	4. How **professional** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	4. How **professional** does this student clinician appear? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely
5. How **comfortable** does this student clinician make you feel? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	5. How **comfortable** does this student clinician make you feel? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	5. How **comfortable** does this student clinician make you feel? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	5. How **comfortable** does this student clinician make you feel? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely	5. How **comfortable** does this student clinician make you feel? 1 2 3 4 5 6 7 8 9 10 Somewhat ... Extremely

Section B – Student Clinician Attire – Preferences

Which student clinician would you prefer?
How would you order the following student-clinician pictures (1 = prefer the most and 5 prefer the least) related to your perception of the student-clinician competency and knowledge?

A	B	C	D	E
				
1-2-3-4-5	1-2-3-4-5	1-2-3-4-5	1-2-3-4-5	1-2-3-4-5

Section C-1 – General Student Clinician Attire

Please indicate your level of agreement with the following statements by checking ONE box to the left of your answer.

1 How my student-clinician dress is important to me.
_ Strongly Disagree
_ Disagree
_ Neither Agree nor Disagree
_ Neither Agree nor Disagree
_ Agree
_ Strongly Agree

2) How my student clinician dress influences how happy I am with the care I receive.
_ Strongly Disagree
_ Disagree
_ Neither Agree nor Disagree
_ Neither Agree nor Disagree
_ Agree
_ Strongly Agree

3) It is appropriate for a student clinician to dress casually when seeing patients over the weekend.
_ Strongly Disagree
_ Disagree
_ Neither Agree nor Disagree
_ Neither Agree nor Disagree
_ Agree
_ Strongly Agree

4) Student clinicians should wear a white coat when seeing patients in the student clinic.
_ Strongly Disagree
_ Disagree
_ Neither Agree nor Disagree
_ Neither Agree nor Disagree
_ Agree
_ Strongly Agree

Section C-2 – General Supervising Clinician Attire

Please indicate your level of agreement with the following statements by checking ONE box to the left of your answer.

1) How the supervising chiropractor dress is important to me.
_ Strongly Disagree
_ Disagree
_ Neither Agree nor Disagree
_ Neither Agree nor Disagree
_ Agree
_ Strongly Agree

2) How the supervising chiropractor dress reflects how knowledgeable they appear.
_ Strongly Disagree
_ Disagree
_ Neither Agree nor Disagree
_ Neither Agree nor Disagree
_ Agree
_ Strongly Agree

3) How the supervising chiropractor dress reflects how trustworthy they appear.
_ Strongly Disagree
_ Disagree
_ Neither Agree nor Disagree
_ Neither Agree nor Disagree
_ Agree
_ Strongly Agree

4) How the supervising chiropractor dress reflects how professional they appear.
_ Strongly Disagree
_ Disagree
_ Neither Agree nor Disagree
_ Neither Agree nor Disagree
_ Agree
_ Strongly Agree

Section D – Demographic (Please remember that all of your answers will be kept confidential)

1) How old are you (in years)?

2) What is your gender?
_ Male
_ Female
_ Other
_ Decline to answer

3) What is the highest level of education you have completed?
_ Less than high school
_ High School
_ Tafe
_ University Undergraduate
_ University Postgraduate

4) What is your ethnicity
_ Australian
_ Indigenous Australian or Torres Strait Islander
_ New Zealander
_ Middle Eastern
_ African
_ Other? Please specify:
_ Asian
_ European
_ Indian
_ American
_ Decline to answer

5) How often have you been to this clinic?
_ First time
_ Visit 2 – 3
_ Visit 4 – 8
_ Visit > 8

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Recreational windsurfing-related acute injuries: a narrative review. Part 1: injury epidemiology and a proposal for standardized injury definitions

Chun-Cheung Woo, DC, MCSportsSc, ICSSD[1]

Objective: *The purpose of this review was to identify the epidemiology of, and develop standardized injury definitions for, acute injuries among recreational windsurfers*.

Methods: *A literature search was conducted from the PubMed and Google Scholar databases through February 28, 2023, using relevant keywords with Boolean operators, such as "windsurfing" AND "epidemiology" AND "risk factors." Only peer-reviewed, relevant windsurfing-related injury articles were included*.

Results: *A wide range of acute injuries, from minor, moderate, severe, to catastrophic, were reported. Injury*

Blessures aiguës liées à la pratique récréative de la planche à voile: une étude narrative. Partie 1: épidémiologie des blessures et proposition de définitions normalisées des blessures

Objectif: *Le but de cette étude était d'identifier l'épidémiologie des blessures aiguës chez les véliplanchistes amateurs et d'élaborer des définitions normalisées de ces blessures*.

Méthodologie: *Une recherche documentaire a été effectuée dans les bases de données PubMed et Google Scholar jusqu'au 28 février 2023, en utilisant des mots clés pertinents avec des opérateurs booléens, tels que "windsurfing" AND "epidemiology" AND "risk factors" (planche à voile ET épidémiologie ET facteurs de risque). Seuls les articles pertinents sur les blessures liées à la planche à voile, examinés par des pairs, ont été retenus*.

Résultats: *Un large éventail de blessures aiguës, allant de mineures à catastrophiques, a été rapporté*.

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rates, frequency of anatomical distributions, existing and potential risk factors, the proposed standardization definitions of behaviour types, skill levels, general windsurfing-related injuries, and injury severity classifications and levels for windsurfing epidemiology were identified and tabled.

Conclusions: *There is inconsistency in the epidemiological methods and definitions of windsurfing research. The injury rates remain difficult to compare among the identified studies. Future in-depth windsurfing-related injury studies should focus on prospective designs using standardized injury definitions.*

(JCCA. 2023;67(2):142-158)

KEY WORDS: acute injuries, causes, chiropractic, demographics, epidemiology, injury definitions, injury patterns, mechanisms, risk factors, sports behaviour, sports nutrition, windsurfing

Les taux de blessures, la fréquence des répartitions anatomiques, les facteurs de risque existants et potentiels, les définitions de normalisation proposées pour les types de comportement, les niveaux de compétence, les blessures générales liées à la planche à voile, ainsi que les classifications et les niveaux de gravité des blessures pour l'épidémiologie de la planche à voile ont été déterminés et présentés.

Conclusions: *Les méthodes et définitions épidémiologiques de la recherche sur la planche à voile manquent de cohérence. Les taux de blessures restent difficiles à comparer entre les études retenues. Les futures études approfondies sur les blessures liées à la planche à voile devraient se pencher sur des modèles prospectifs utilisant des définitions de blessures standardisées.*

(JCCA. 2023;67(2):142-158)

MOTS CLÉS : blessures aiguës, causes, chiropratique, démographie, épidémiologie, définitions de blessures, modèles de blessures, mécanismes, facteurs de risque, comportement sportif, nutrition sportive, planche à voile.

Introduction

Injuries are unavoidable for both recreational and elite-level competitive windsurfers.[1] Three types of windsurfing-related injuries have been identified: a wide range of *acute* injuries[2-4] from minor, moderate, and severe to catastrophic injuries, such as spinal and spinal cord injuries,[5,6] and drowning death;[2,6,7] *overuse* injuries,[3,4] such as low back pain,[3,8] and entrapment of the posterior interosseus nerve;[9] and *overexposure* or prolonged-exposure injuries, such as sunburn,[4,10] life-threatening hypothermia,[2,4,6,7] and external auditory exostosis[11].

Little is known about sports chiropractic involvement in windsurfing-related injury research. One chiropractic retrospective survey questionnaire study provided data on physical characteristics and acute and overuse injuries, including low back pain, in nine elite women windsurfers.[3] Another chiropractic retrospective survey questionnaire study of low back pain and harness use in windsurfing provided data on prevalence and found that 152 of 400 high-wind windsurfers showed a 93.3% prevalence of low back pain among the windsurfers versus 75.7% among the control group.[8]

Injury epidemiology can be regarded as a "cornerstone" for the evidence-based practice of sports medicine. Sports injury epidemiological data has helped to identify causes of injuries and has been used to reduce injury rates evidently by developing and implementing prevention strategies such as the prohibition of "spearing" in football[12] and strict judging and heavy penalties for uncontrolled blows in karate[13]. Until recently, relatively little research using standardized epidemiological methods has been addressed. To encourage consistency in the definitions and methods used, and to enable data across studies to be compared, 11 international sport-specific or setting-specific consensus papers on standardized injury epidemiology have been published.[14]

There is limited data on the epidemiology of windsurfing-related acute injuries. To date, the demographic characteristics and injury characteristics, such as injury rates, risk factors, patterns, causes, and mechanisms of recrea-

tional windsurfing-related acute injuries, are largely unclear. Standardized injury definitions for windsurfing-related injuries are needed. The severe and catastrophic windsurfing-related acute injuries highlight the need for injury prevention studies. To provide clinicians with a practical overview of injury epidemiology and preventive strategies, the narrative review of "recreational windsurfing-related acute injuries" is organized into two parts:

Part 1: injury epidemiology and a proposal for standardized injury definitions.
Part 2: injury prevention and a proposal for a set of potential prevention strategies with a holistic approach.

The purpose of this review was to identify the epidemiology of, and develop standardized injury definitions for, acute injuries among recreational windsurfers. The research question, "What are the existing injury characteristics regarding windsurfing-related injuries, definitions, demographic characteristics, injury severities, injury rates, factors, patterns, causes, and mechanisms for recreational windsurfing-related acute injuries?", was developed.

Methods

A literature search was conducted from inception up to February 28, 2023, for recreational windsurfing-related acute injuries. The PubMed and Google Scholar electronic databases were searched. In addition, manual searching of reference lists was used to identify additional articles with Google Scholar.

Search strategy

To provide the most articles pertaining to the research question, the search method was broken down into the following categories using the Boolean operator and relevant keywords: "injury epidemiology" AND "windsurfing" OR "boardsailing," "demographic characteristics "AND "windsurfing" OR "boardsailing," "acute injury" AND "windsurfing" OR "boardsailing," "injury definition" AND "windsurfing" OR "boardsailing," "injury severity" AND "windsurfing" OR "boardsailing," "injury rates" AND "windsurfing" OR "boardsailing," "risk factors" AND "windsurfing" OR "boardsailing," "injury pattern" AND "windsurfing" OR "boardsailing," "injury causes" AND "windsurfing" OR "boardsailing," "injury mechanism" AND "windsurfing" OR "boardsailing," and "behavior" AND "windsurfing."

Inclusion and exclusion criteria

For the inclusion criteria for relevant articles, data were collected on at least one outcome related to demographic characteristics, injury types, anatomical locations, injury severities, injury rates, risk factors, injury patterns, and mechanisms of recreational windsurfing-related acute injuries. Only peer-reviewed English-language articles on windsurfing-related acute injuries were included. Articles were excluded if their contents were duplicated, ambiguous, or unavailable in English. Boat sailing, stand-up paddle-sailing, or kite-sailing were excluded.

Article selection

A PRISMA-type flow chart was used to provide information through the different phases of the study selection process of *identification*, *screening*, *eligibility*, and *inclusion* of citations into the final review. Articles were identified through a preliminary search. Duplications were removed. Articles were initially screened by title and abstract for eligibility. Full-text materials were then assessed for eligibility and finally included in the full-text review. Article screening, selection, and reviewing were done by the author exclusively.

Data extraction

The titles, authors, year of publications, objectives, study designs, number of participants, settings, locations, demographic characteristics, injury characteristics, including risk factor classification (intrinsic/extrinsic), and acute windsurfing-related injuries were extracted. All data were reviewed for relevance.

Results

The preliminary search identified 297 articles. 47 articles were included in the final review from 87 publications assessed for eligibility (Figure 1). Regarding the study designs, only retrospective study data (hospital record reviews and questionnaires) and prospective study data (telephone interviews and questionnaires) were identified. Regarding injury epidemiology, injury rates for recreational windsurfers of different skill levels in different countries were summarized in Table 1; the frequency

of anatomical distributions of windsurfing-related acute injuries of recreational and professional skill levels was summarized in Table 2; and the existing and potential injury risk factors of windsurfing-related acute injuries were summarized in Table 3. There was inconsistency in the injury epidemiological definitions of windsurfing research. To encourage consistency in the definitions for standardized epidemiological research, the proposed standardization definitions of behaviour types, skill levels, and general windsurfing-related injury were summarized in Table 4, and injury severity classifications and levels for windsurfing epidemiology were summarized in Table 5, respectively.

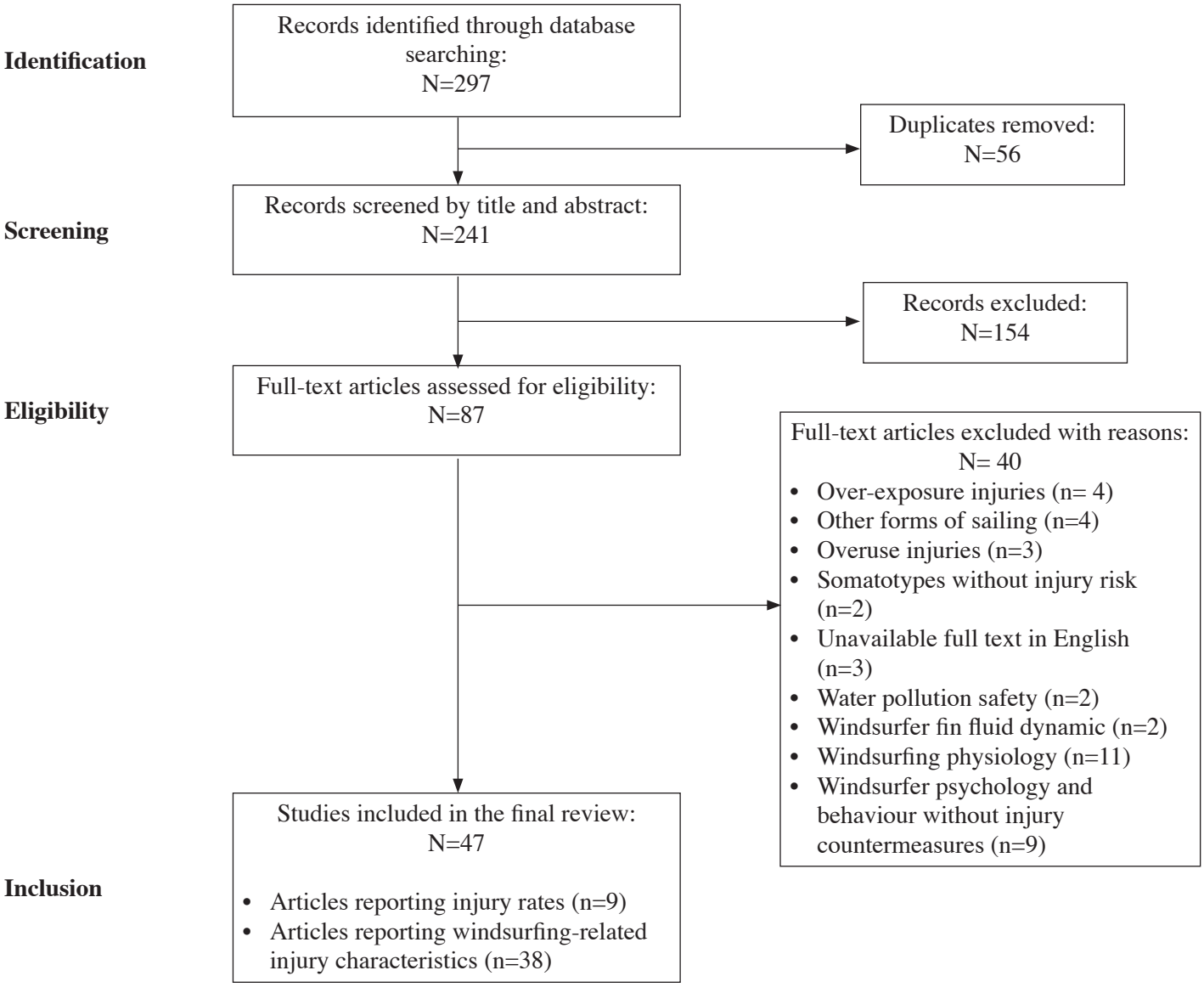

Figure 1.
Summary of a PRISMA-type flow chart of information through the different phases of the article selection process.

Table 1.
Summary of injury rates for recreational windsurfers of different countries

Study	Study design and duration of collection (if available)	Total number (n) of participants (including gender)	Country, skill level, and number (n) of participants	Injury rates (Expressed as number of injuries/1000 hours exposure, and/or number of injuries/ athlete/year) (Recreational windsurfers, if available)
McCormick, Davis 1988 [10]	Retrospective study (A review of medical hospital records for the period 1976-1986, and survey questionnaire-interview)	n=73 (51 men, 22 women)	Windsurfers from United States: • *Novice:* all men n=16 (31%), all women n=10 (45%); • *Intermediate:* all men n=29 (57%), all women n=11 (50%); • *Expert:* all men n=6 (12%), all women n=1 (5%); and • *"Hurricane man"* (40 knots): n=6 (60%)	• Overall: 0.22/1000 hours windsurfing. (*Recreational windsurfers*)
Mettler, Biener 1991 [36]	Retrospective study (A review of medical record)	n =189	Windsurfers from Swiss Windsurfing Federation: • National-level windsurfers.	• Overall: 0.02/athlete/year.
Salvi-et al. 1997 [26]	A retrospective study between June to October 1993 evaluating acute and overuse injuries of muscle and bone.	n=123 (118 men, 5 women)	Windsurfers from Italy (*national/international*): • Competitive slalom, course racing, & wave n=76; • Competitive slalom & wave, n-35; and • Competitive slalom & course racing, n=22.	• Overall: 0.22/1000 hours activity, 0.003/athlete/year. • Acute injuries: 0.128/1000 hour activity, 0.0019/athlete/ year.
Nathanson, Reinert 1999 [7]	A retrospective study of an internet survey specific questionnaire between February 1997 and May 1997 and an identical paper survey distributed to windsurfers at beaches in the US and Dominican Republic between April 1994 and April 1997.	n=294 (90% men including 2 expert professionals)	Windsurfers from 24 countries, majority (67%) were from United States: • *Beginner:* n=21 (7%); • *Intermediate*: n=176 (60%); and • *Expert*: n=95 (32.3%).	• Overall:1/1000 hours sailing. Predominantly *recreational* windsurfers n=292 (99.3%).
Lim et al. 2003 [37]	A retrospective & prospective telephone interview study with structured questionnaires over 1 year.	n=64	Windsurfers from Britain: • Competitive amateur shortboard including wavesailing and slalom (*national*).	Overall: 2.6/1000 hours • During training: 2.3/1000 hours • During competition: 3.7/1000 hours
Dyson et al. 2006 [1]	A retrospective study of a paper survey specific questionnaire distributed to windsurfers at the event site and collected by hand in the 1999/2000 seasons	n=107 (88 men, 19 women)	Windsurfers from United Kingdom: *Recreational* group: n=28; • *Competitive raceboard* group *(national/ international):* n=36; and • *Competitive wave/slalom* group *(national/ international):* n=43.	• Overall: 1.5/person/year; • *Recreational group*: 1.2/ person/year • *Raceboard group*: 1.0/person/ year; • *Wave/slalom group*: 2.0/ person/year.
Kucera, Psalman 2015 [38]	Retrospective study (Questionnaire)	n =104	Windsurfers from Czech Republic: • *Recreational group A:* n=35, funboard including slalom & wave with free style acrobatic/aerial maneuvers; • *Raceboard group B (national):* n=45; and • *Raceboard group C (professional):* n= 24.	• *Recreational group:* 2.63/athlete/year. • *Raceboard (national)* group: 1.04/athlete/year. • *Raceboard (professional) group*: 0.63/athleteyear.
van Bergen et al. 2016 [27]	A retrospective study of hospital medical record review from September 2009 through September 2011 and a postal questionnaire. Hospital record: windsurfing group n= 25 (21 men, 4 women).	n=18 completed questionnaire	Windsurfers from Netherlands: • Beginner: n=1; • Intermediate: n=0; • Advanced: n=9; and • Expert: n=8.	• Overall: 5.2/1000 hours windsurfing. (*Recreational windsurfers*)
Minghelli et al. 2019 [39]	Retrospective study (Questionnaire)	n =58	Windsurfers (*World Championships*) from Portugal: • *Competitive raceboard*: n=27; and • *Competitive Windsurfing Formula*: n=31.	• Overall: 3.91 injuries/1000 hours windsurfing training.

Table 2.

Summary of the frequency of anatomical distributions of windsurfing-related acute injuries

1. Frequency of body regions

Study	Study design	Total number (n) of participants and skill levels	Frequency of body regions (%) in decreasing order (Number of acute injuries)
Nathanson, Reinert. 1999 [7]	Retrospective study (a paper- & internet-based survey) Paper-based survey collected between April 1997 & April 1994 and an internet-based survey between February 1997 & May 1997.	n= 294 windsurfers: • 292 recreationalists • 2 professionals	n=339 acute injuries • Lower extremity (44.6%) • Upper extremity (18.5%) • Head & neck (17.8%) • Trunk (16%)
Gosheger et al. 2001 [54]	Retrospective study (Survey questionnaire)	n=49 windsurfers: • 49 professionals (10 women, 31 men)	n=260 acute injuries • Lower extremity 59% • Head (17%) • Trunk (15%) • Upper extremity (9%)
Hopkins, Hooker. 2002 [15]	Retrospective study (Emergency department database review between April 1, 1995, & September 30, 1998)	n=220 windsurfers	n=222 acute injuries • Lower extremity (48%) • Head/neck (25%) • Trunk (9%) • Upper extremity (8%)
Kucera, Psalman. 2015 [38]	Retrospective study	n=104 windsurfers: • 35 recreationalists • 45 nationals • 24 professionals	*Recreational level* (funboarding, wave, & slalom) n=92 acute injuries • Lower extremity (42%) • Head & neck (23%) • Upper extremity (20%) • Trunk (15%) *National level* (race-boarding) n=37 acute injuries • Upper extremity (52%) • Lower extremity (26%) • Head & neck (13%) • Trunk (9%) *Professional level* (race-boarding) n=15 acute injuries • Upper extremity (53%) • Lower extremity (27%) • Head & neck (13%) • Trunk (7%)
Van Bergenet al. 2016 [27]	Retrospective study (Review of hospital records between 2009 through September 2011)	n=25 windsurfers	Number of injuries per 1000 h Affected body site (number & % of patient) • Lower extremity 10 (40%) • Head & cervical spine 9 (36%) • Upper extremity 6 (24%) • Trunk & thoracolumbar spine 0 (0%)

2. Frequency of body parts

Study	Study design	Total number (n) of participants and skill levels	Frequency of body parts (%) in decreasing order (Number of acute injuries)
Ullis, Anno. 1984 [25]	Retrospective study (Survey questionnaire) Data collected at 3 events in 1982.	n=57 windsurfers: (14 female, 43 male) • 30.2% recreationalists • 69.8% professionals	*Female windsurfers (n=14)* Skin 100%, Shins 100%, feet 100%, back 71.4%, forearms 71.4%, shoulder 64.3%, head 57.1%, neck 57.1 %, fingers 50%, chest 42.5%, thighs 35.7%, elbows 28.6%, wrist 21.4%, ears 21.4%, eye 14.3%, mouth, throat, and teeth 14.3%, knee 7.1%, ankle 14.3%, abdomen 7.1%, genitalia 7.1% *Male windsurfers (n=43)* Skin 100%, feet 95.3%, back 79.1%, shins 77.6%, forearms 60.5%, head 55.8 %, neck 51.2%, fingers 48.8%, shoulder 39.5%, knee 39.5%, ankle 34.9%, ears 34.9%, chest 39.5%, genitalia 29.5%, eyes 27.9%, elbows 27.9%, thighs 23.3%, wrist 16.3%, mouth, throat, and teeth 19.3%, nose 9.3%, abdomen 2.3%, heart 2.3%
Nathanson, Reinert. 1999 [7]	Retrospective study (paper- & internet-based survey) Paper-based survey collected between April 1997 & April 1994 and an internet-based survey collected between February 1997 & May 1997.	n= 294 windsurfers: • 292 recreationalists • 2 professionals	n=339 acute injuries Foot 17.7%, knee 9.4%, chest wall 8.9%, ankle 8.6%, head 7.4%, leg 7.4%, shoulder 7.1%, back 6.8%, neck 4.7%, hand 4.4%, face 3.5%, wrist 3.5%, arm 3.2%, other 2.9%, toe 1.5%, eye 0.9%, nose 0.9%, teeth 0.9%. elbow 0.3%

Table 3.
Summary of the existing and proposed potential injury risk factors for windsurfing-related acute injuries

Intrinsic risk factors	Extrinsic risk factors
Demographic characteristics: • Age (older) [15,16,18] • Gender [15,17] • Body size (height and weight) [3,19] and composition (body mass index) * • Somatotypes: endomorph (fatness), mesomorph (muscularity), and ectomorph (linearity) * *Physiological characteristics: ** • Physical fatigue • Physical fitness • Aerobic fitness • Muscle strength, imbalance, tightness, and fatigue • Joint mobility (ligament laxity, flexibility, hypermobility, and hypomobility) • Neuromuscular proprioception control (slow reaction time) • Balance (static and dynamic) *Biomechanical factors: ** • Spinal mobility and core stability • Sacroiliac joint dysfunction • Pelvic girdle insufficiency (ligament laxity) • Internal rotation of the hip • Genu valgus and varum • External rotation of the tibia • Leg length discrepancy • Foot (pronation), pes planus, and pes cavus *Nutritional conditions:* • Fluid consumption (insufficient and incorrect hydration) [50] • Food consumption (insufficient nutrition) [20] *Behaviour factors:* • Adventurous risk-taking behaviour [4,44] (expectations, motivations, and pressures) • Alcohol consumption [4] (prior training or competition) • Drug abuse [4] (prior training or competition) *Medical conditions:* • Previous injuries and inadequate rehabilitation • Epilepsy [10] • Cardiovascular diseases [10] • Diabetes * • Asthma *	*Equipment conditions:* • Equipment (poorly maintained, worn, and damaged) [47] • Sizes (board, sail, [4,23,24] and fin) • Design safety (fin hazards) [7,26] *Environmental conditions:* • Unknown venue [4] • Strong wind forces (overpowering) [4,24,48] and direction (offshore winds [29]) • High waves [4,24,28] • Current [48] (rip current) • Weather [4,24] (sunny,[62] heavy rainfall, lightning, poor visibility fog or mist, cold or hot temperature, and high humidity) • Sea animals (sharks, needlefish, and jellyfish) [2,10,29] *Discipline types:* • Wave (jumping maneuvers) [1,23,25] • Slalom [1,26] • Course racing [1,26] • Freestyle (acrobatic or aerial maneuvers) [18,38] *Training parameters: ** • Training load and fatigue (schedule congestion or overtraining) • Training exposure times • Training techniques (incorrect) • Incorrect physical preparations • Training recovery (short and insufficient) *Competition parameters: ** • Competition load and fatigue (over-competition) • Competition exposure times • Skill levels [38] • Levels of competition • Competition demands (a large number in the year) • Competition recovery (short and insufficient)

Adopted from [1-4,7,10,15-18,20,23-26,28,29,38, 44,47,48,50,62], and modified from [42] with potential risk factors. (*)

Table 4.
Proposal for standardization of definitions of windsurfing-specific behaviour types and skill levels and general windsurfing-related (or other sports-related) injuries

Behaviour types (windsurfing-specific)	A. Behaviour types and definitions of recreational windsurfers [22] • *Occasional recreational windsurfers* are defined as beginner-level athletes who prefer *middle (4-7 m/s) wind speeds* over *strong (8 m/s and over) wind speeds* and prefer only summer conditions with high crowding. • *Social recreational windsurfers* are defined as intermediate-level athletes who prefer middle wind speeds over strong winds and summer and spring conditions with higher crowding. • *Competitive recreational windsurfers* are defined as experienced *non-professional* competitive athletes who prefer strong wind in the summer over spring conditions with high crowding. • *Pleasure recreational windsurfers* are defined as experienced, aggressive athletes who prefer strong wind speeds in the summer over spring conditions with high crowding.
Skill levels (windsufing-specific)	B. Skill levels and definitions of recreational windsurfers [1,10] • *Beginner level* is defined as an inexperienced novice windsurfer with learning and training skills equivalent to a basic windsurfing course. • *Intermediate level* is defined as an experienced windsurfer with learning and training skills equivalent to an intermediate windsurfing course. • *Advanced level* is defined as an elite experienced windsurfer with learning and training skills equivalent to an advanced windsurfing course (such as advanced slalom skills, advanced aerial and freestyle maneuvers, or advanced wave jumping and sailing maneuvers). • *Expert level* is defined as an extremely experienced windsurfer with skills above advanced level and capable of sailing in *gale-force winds* with 40 knots 10 and *high waves*.
General windsurfing-related (or other sports-related) injury definitions	C. General windsurfing-related (or other sports-related) injury definitions (modified from [59]) • *Acute windsurfing (sports) injury* is defined as the damage to body site(s) of sudden onset sustained by an athlete that resulted during windsurfing (sports) training or competition, irrespective of the need for medical attention or time loss from or incapacity to windsurfing (sports) activities. • *Injury severity* is defined as the inability to train or complete windsurfing (sports) normally, with several days having elapsed from the date of the injury to the date of the athlete's return to full training and competition. The absence from windsurfing (sports) can range from more than 1 day, more than 6 weeks, to a permanent disability. • *A sports-related medical attention or intervention injury* is defined as an injury that results in an athlete receiving "medical attention (intervention)" by qualified healthcare practitioners. • *A sports-related time-loss injury* is defined as an injury that results in an athlete being unable to take part in windsurfing (sports) training or competition. • *A sports-related recurrent injury* is defined as an injury of the same type and at the same site as an index windsurfing (sports) injury that occurs after an athlete's return to full participation from the index injury. Also, a recurrent injury may not necessarily need to be identical in severity to be considered recurrent. • *Early recurrence* is defined as a sports-related recurrent injury occurring within 2 months after an athlete's return to full participation. • *Late recurrence* is defined as a sports-related recurrent injury occurring 2-12 months after an athlete's return to full participation. • *Delayed recurrence* is defined as a sports-related recurrent injury occurring more than 12 months after an athlete's return to full participation.

Adopted and modified from [1,10,22,59]

Table 5.
Proposal for standardization of definitions of injury severity classifications and levels for windsurfing (or other sports)

Injury severity classifications and Levels (1-4)	**Definitions of athletic injury severity for windsurfing (or other sports)**	**Medical attentions (interventions)**	**Consequences of acute athletic injuries for windsurfing (or other sports)**
Minor Level (1)	• A *minor injury* is defined as an *injury from windsurfing (or other sports) resulting in the inability to train or complete sports normally*. • An athletic injury is temporary and self-limited but requires first-aid management.	• Management by qualified sports first aiders is needed. • Medical attention by qualified primary healthcare providers and athletic trainers is not required.	• *No time loss* or • May result in an inability to train or compete in windsurfing (or other sports) normally.
Moderate Level (2)	• A *moderate injury* is defined as an *injury from windsurfing (or other sports) resulting in absence for more than 1 day*. • An athletic injury is temporary and curable, and it is reversible in most instances.	• Medical attention by qualified primary healthcare providers may be required. • Neuromusculoskeletal sports rehabilitation may be required. • An emergency department visit may be required. • Hospitalization is not required.	• *Time loss* • Absence from windsurfing (or other sports) for *not more than 6 months* • Not life-threatening
Severe Level (3)	• A *severe injury* is defined as an *injury from windsurfing (or other sports) resulting in absence for 6 weeks to more than 6 months*. • An athletic injury is irreversible and may cause long-term disability.	• Medical attention by qualified healthcare specialists is required. • Neuromusculoskeletal sports rehabilitation is required. • A tertiary hospital and hospitalization are required.	• *Time loss* • Absence from windsurfing (or other sports) for *more than 6 months* • Not life-threatening
Catastrophic Level (4)	• A *catastrophic injury* is defined as an *injury from windsurfing (or other sports) resulting in permanent disability, a life-threatening condition, or death*. • An athletic injury may be associated with critical accidents, such as near-drowning, drowning, spinal injuries, spinal cord injuries, and loss of limbs.	• Intensive care with advanced life support is required. • If the injured athlete survived, tertiary hospital multidisciplinary medical and other interventions, such as neurological, physical, mental, and respiratory rehabilitation, are required.	• *Permanent time loss* • Loss of limb(s) or • Permanent disability or • Life-threatening or • death

Adopted and modified from [27, 60,61]

Demographic characteristics and windsurfing-related injuries – Age and gender

Windsurfing is a sport for young to middle-aged people, predominantly men.[15] The average age of windsurfing injuries was 35 years old, ranging from 12 to 68 years of age;[15] and 10% were older than 50 years of age[16]. The ratio of male to female injuries is 9:1.[7,15] Men windsurfers are injured more frequently during competition than training (79.5%, $p<0.05$, vs 22.2%);[17] and women windsurfers are injured more frequently during training than competition (77.8%, $p<0.05$, vs 20.5%)[17,18]. Women windsurfers are more likely to suffer serious injuries during training sessions.[17] Freestyle involves a greater risk of leg injuries for women.[18] The knee is the most injured area, both for men and women, followed by the leg.[17]

Anthropometric characteristics

Data about the anthropometric characteristics of windsurfing-related injuries is sparse. In one retrospective survey study of 41 elite windsurfers, the heights of 36 male (age range: 15-44 years) and five female (age range: 15-39 years) elite windsurfers ranged from 1.65-1.90 m and 1.55-1.70 m, respectively, and their weights ranged from 55-94 kg and 50-64 kg, respectively.[19] The study also indicates that elite windsurfers suffer predominantly minor acute injuries, which are mainly abrasions and lacerations to the lower limbs. Another retrospective study of the physical characteristics and injuries of nine elite women world champions (age range: 23-34 years) found that no serious acute injuries in the organized windsurfing competition were reported, and only one case of an acute minor lower leg contusion injury by sailboard during freestyle was found. Their height ranged from 1.62-1.78 m (mean =1.69 m) and their weight ranged from 56-64 kg (mean = 60 kg). In another study of anthropometry among 91 windsurfers of different disciplines, the wave or freestyle group (n = 46) demonstrated lower percentages of body fat (21%), circumferences, skinfolds, body mass index (23.9 kg/m^2), and fat mass index (5.1 kg/m^2) compared with the slalom or formula group (n = 45) (body fat 25.2%, body mass index 26.1 kg/m^2, and fat mass index 6.6).[20] A very recent anthropometric study of 21 young elite windsurfers (age range = 12-18 years) found that the high-level performance elite windsurfers had a greater percentage of arm muscle mass and leg muscle mass compared to low-level performance windsurfers.[21]

Behavioural types

A conjoint analysis was used to examine windsurfing preferences. Three attributes— wind velocity, season, and crowding— were considered.[22] Four behavioural types of recreational windsurfers were identified: occasional, social, competitive, and pleasure windsurfers. The definitions of four behavioural types are summarized in Table 4A. Regarding wind speed preferences, occasional and social windsurfers prefer middle wind speeds, and competitive and pleasure windsurfers prefer strong wind speeds.[22] However, the frequency of windsurfing-related injuries among different behavioural types of windsurfers is unknown.

Skill levels

Four skill levels of recreational windsurfers were found: *beginner* (7%,[7] 31% men, and 45% women10), *intermediate* (60%,[7] 57% men, and 50% women10), *advanced* [1], and *expert* (33%,[7] 12% men, and 5% women10). Inexperienced beginners and intermediate athletes,[2] especially women,[10] appear to have an increased injury risk in recreational windsurfing. The definitions of the four skill levels of recreational windsurfers are summarized in Table 4B.

Acute windsurfing-related injuries

A wide range of acute windsurfing-related injuries, from minor to moderate to severe to catastrophic, were reported. Most windsurfing-related injuries occur when doing jumps in wave conditions.[23] The frequency of anatomical distributions of windsurfing-related acute injuries is summarized in Table 2. Most recreational windsurfers sustained minor injuries, such as abrasions, lacerations, contusions, strains, and sprains;[1,3,7,10] and 43% of new injuries were muscle and tendon strains[1]. According to a retrospective study of hospital records from the emergency department,[15] the frequency of 222 cases of windsurfing-related injuries was as follows: laceration (36%), contusion (21%), fracture (14%), sprain (7%), dislocation (4%), and strain (3%). Recreational windsurfers sustained serious acute injuries[7] when they practiced in overpowering winds and wave conditions[4,24] or simply did not follow safety rules and procedures[4].

Spinal injuries and pelvic injuries

Studies showed that recreational windsurfers sustained fewer acute back (6.8%) and neck (4.7%) injuries,[7]

whereas professionals sustained more acute back (women 71.4% and men 79.1%) and neck (women 57% and men 51%) injuries[25] (Table 2). Acute moderate neck strain, upper back strain, and lower back injuries,[1,25] as well as serious pelvic injuries and non-catastrophic and catastrophic spinal injuries, caused by windsurfing-related accidents, have been documented[2,5-7,25-28]. Head and cervical spine injuries make up 36% of all injuries.[27] Reported serious spinal and pelvic injuries are the cervical (C) spine injuries,[1,7,27] such as a cervical sprain;[26] lateral wedging of thoracic (T8/9) disc;[5] lumbar spine injuries;[6] intervertebral disc herniations;[2,7,25] and pelvic injuries with sacral fractures and pubic symphysis diastasis[28]. Reported catastrophic spine and spinal cord injuries include thoracic spine injuries with pain and transient thoracic spinal cord injuries, cervical spine (C2) fracture, and tetraplegia.[5,6]

Extra-spinal injuries

Studies showed that recreational windsurfers sustained more lower extremity (44.6%) and fewer upper extremity acute injuries (18.5%),[7] whereas professionals sustained more upper extremity (53%), and fewer lower extremity (27%) acute injuries (Table 2). Reported acutely serious and catastrophic extra-spinal windsurfing-related injuries include shark bites,[2,29] axillary artery tear,[30] head injuries,[7,27] concussions,[1,6,25] eye injuries,[7] hearing injuries with tympanic membrane rupture,[1,6,7,15] teeth injuries,[7] nasal fractures,[7] pectoris major muscle rupture,[31] rib fractures with pneumothorax,[2,4] shoulder fractures and dislocations,[4,6,32] arm, elbow, wrist, and hand injuries with fractures[2,7,25] or finger dislocations,[1] knee injuries with anterior cruciate ligament and medial collateral ligament sprains or meniscus tears,[7,33,34] leg, ankle, and foot injuries[7] with Lisfranc fracture-dislocations,[35] drownings, and near-drownings or drowning deaths[2,6,7].

Injury rates

Windsurfing injury rates for different skill levels of recreational windsurfers among national [1,10,26,27,36-39] and international[7] athletes are summarized in Table 1. The existing incidence rate of windsurfing-related acute injuries varied in the definition of injury, study design, methods of data collection, and observational period. The injury rates of these non-standardized epidemiology studies for recreational windsurfers[1,7,10,26,27,37-39] remain difficult to compare among studies due to heterogeneity.

Injury risk factors

Intrinsic and extrinsic risk factors

According to Meeuwisse's model,[40] the risk factors are traditionally classified as intrinsic and extrinsic.

- *Intrinsic risk factors* are defined as individual, biological, and psychosocial characteristics that predispose an athlete to injury.[41]
- *Extrinsic risk factors* are defined as external factors that can cause an athletic injury and are closely related to the type of athletic activity performed.[41]

Windsurfing-related injury risk factors

Based on a systematic review of soccer players' risk factors[42] and the extracted data from this review, existing and potential windsurfing risk factors are summarized in Table 3. Intrinsic risk factors and strategies for injury prevention have been highlighted.[41] However, a multifactorial approach should be used to account for all the intrinsic and extrinsic risk factors as well as injury mechanisms.[43] Windsurfing-related accidents may result from modifiable high-risk, reckless behaviours,[4,44] when certain basic rules, such as the rules of the water or procedures, are violated[4]. Surprisingly, alcohol consumption was found in 22% (4 out of 18) of windsurfers three hours before sailing.[4] *Non-modifiable medical risk factors*, such as epilepsy attacks,[45] and heart attacks[10,46] have been identified.

Environmental risk factors

Extrinsic environmental risk factors, such as Beaufort wind force and rough weather conditions,[4] should be checked for windsurfing suitability before sailing. The Beaufort scale number ranges from 0 (calm) to 12 (hurricane), with wind speeds ranging from under 1 knot to over 63 knots.[47] Underestimation of weather conditions[24] or unawareness of rough weather conditions[4] may increase the risks of accidental injuries.

Equipment-related risk factors

The equipment used in windsurfing has the potential to cause or contribute to *equipment-related injuries*. A retrospective study of 189 windsurfers found that one-third of all injuries were due to board contact events, and 19% were due to falls on the mast.[36] Another retrospective

study found that direct injury from windsurfing equipment resulted in 64.5% of all 339 acute injuries: 17.2% from the boom, 16.7% from the foot straps, 12.7% from the mast, 8.7% from the board, and 8.1% from the fin.[7] Most accidents happen because of an overpowering situation,[4,24,48] i.e., the sail is too big for the wind force[48]. The overpowering situation should be prevented by choosing the right board and sail size.[24]

Sports nutrition risk considerations

Study evidence has revealed that glycogen is the predominant energy fuel during windsurfing pumping.[49] However, a previous dietary quality study found that the overall negative energy balance was due to crucial glycogen depletion between different windsurfing disciplines.[20] Also, a recent study of the assessment of nutrition status in amateur windsurfers found that daily fluid consumption was insufficient.[50] It is important to be aware that the combination of exercise and high environmental heat stress can produce dehydration,[51] and dehydration can hamper performance, including through cognitive impairment and increased injuries[52].

Injury patterns

Clinicians should have a basic knowledge of injury patterns and the hazards of windsurfing to promote prevention strategies and educate their patients.[53] Identifying injury patterns in windsurfing may help clinicians know what to expect[7] and what prevention strategies to consider[54]. Injury patterns appear similar in both recreational1,[7] and competitive[1,54] windsurfing. Windsurfing-specific equipment-related mechanism-based injury patterns have been reported. For example, a *head-to-equipment collision injury*[7] is mainly caused by a collision with the mast or boom due to high-speed falls;[4] the head injuries can range from minor head injuries to severe brain concussions with loss of consciousness[4]. The *boom-hanging and fall-shoulder injury*[7] is caused by a fall while hanging on the boom to maintain a pull on the sail, leading to an anterior shoulder dislocation[4,7]. Falls may also cause a *foot-fixation injury* (foot strap injury) due to the fixation of the feet in the foot straps.[34]

Causes

In windsurfing, there are several causes of unpredictable traumatic forces in the reported acute injuries, such as the overpowering forces of sudden, unexpectedly strong winds,[5] and high waves,[28] and the pulling, rotating, and collision forces of high-speed and low-speed falls from poorly performed jumping and aerial maneuvers. A retrospective study of 327 windsurfers with an overall 630 accidents found that most accidents happen at Beaufort scales 5-6 (fresh breeze to strong breeze with 17–27 knots[47]) after two hours of exercise.[24] A previous study found that one-third of all acute injuries were caused by board contact, one-fifth happened on the shore, and 19% were attributed to falls on the mast.[48] Collision force with equipment in recreational windsurfers[1,7] when overpowered by wind and waves is the most common reported cause of injury occurrence[1,49,55] and serious injuries,[24] such as spinal injuries[25,56] and spinal cord injuries[24].

Injury mechanisms

The most documented windsurfing injury mechanisms are maneuvering, board impacting, and traction or twisting the fixed foot.[23,44] The identified maneuvers most likely to result in injury are jumping, high-speed falls, catapult falls, and launching[7] or acrobatic maneuvers[55]. Recreational athletes injure themselves due to uncontrolled catapult falls. A previous study found that catapult crashes resulting from jumping maneuvers were the most common type of windsurfing-related accident.[1] In wave-related accidents, neck hyperextension may be the most common mechanism of cervical spine injuries.[57] Low-speed falls[7] may cause knee, leg, ankle, and foot injuries ascribed to the feet's fixation in the foot-straps,[7,34] while high-speed falls[7] in wave-riding may cause head, shoulder, and upper extremity injuries consistent with the mechanism of catapulting[24] mainly caused by the impact of landing on the mast or the boom,[7] or the mechanism of falling while maintaining a pull on the sail with the athlete's arms hanging onto the boom and causing shoulder dislocation[27].

Proposal for standardization of definitions for windsurfing-related injuries

Uniform definitions are important and necessary to enhance the comparability of research data.[58] There is a need to collect and report injury data using standardized windsurfing-related injury definitions to enable data across future studies to be compared. The *general windsurfing-related injury definitions* (Table 4C), including *injury severity*, were modified from the consensus statement on

injury definitions and data collection procedures in studies of soccer injuries.[59]

Injury severity classifications and levels for windsurfing
The reported injury's *four severity classifications* (Table 5) ranged from mild (17%) to medium (33%), severe (44%), and catastrophic (6%).[27] The severity of sports injuries can be described based on six criteria: the nature of the injury, the duration and nature of the treatment, sporting time lost, working time lost, permanent damage, and cost.[58] According to recent safety and risk assessment research,[60] the four *levels of injury severity* (Table 5) are determined by the type of "medical intervention" (such as first aid, a visit to the accident and emergency department, and hospitalization) required for the injury scenario. According to the RAPLEX guidelines,[61] the four *levels of injury severity* are:

- *Level 1*: An injury or consequence that, after basic treatment such as first aid, does not hamper functioning or cause excessive pain; usually the consequences are completely reversible.
- *Level 2*: An injury or consequence for which a visit to emergency may be necessary, but in general, hospitalization is not required. Functioning may be affected for a limited period, not more than about 6 months, and recovery is complete.
- *Level 3*: An injury or consequence that normally requires transportation of the athlete to a tertiary hospital and hospitalization and will affect functioning for more than 6 months or lead to a permanent loss of function.
- *Level 4*: An injury or consequence that is or could be fatal, including brain death; a consequence that affects reproduction or offspring; severe loss of limbs and/or function, leading to more than approximately 10% of disability.

Based on and modified from the RAPLEX guidelines,[61] injury severity levels,[27] and injury definitions,[60] standardized definitions of injury severity classifications, and levels of acute windsurfing-related injuries are proposed (Table 5).

Discussion

It is difficult to compare the injury rates in Table 1. These data [1,7,10,26,27,36-39] have been calculated from non-standardized study designs using different ways of collecting data, sample sizes, injury definitions, disciplines, and skill levels. It is possible that participants underestimated the amount of time they practiced windsurfing during the time of these studies,[27] and thus these data are subject to reporting bias, recall bias,[7] and collecting bias. When similar study designs using a review of hospital medical records and a questionnaire are compared, the injury rate shows remarkable increases, from 0.22/1000 h in the McCormick and Davis 1988 study[10] to 5.2/1000 h in the van Bergen *et al*. 2016 study[27]. This could be attributed to technological development, lighter and more sophisticated materials, and risk-taking behaviour.

In frequency studies [7,15,25,27,38,54] of body regions and body parts of windsurfing-related acute injuries (Table 2), no information was available regarding windsurfing disciplines such as speed, slalom, freestyle, and wave sailing. Future studies should consider including data on skill levels and sporting disciplines.

Windsurfing is not without injury risk, whether the individual windsurfer is an elite athlete or involved only in recreational participation. Windsurfing injury risk is a complex and multifactorial phenomenon. The identification of injury risk factors represents an important step before the implementation of prevention strategies.[58] Multiple intrinsic and extrinsic risk factors have been identified (Table 3). Intrinsic risk factors are those within the athlete's body. For example, risk factors may pertain to age, gender, anthropometrics, previous injuries, and physical, functional, psychological, and medical conditions. Extrinsic risk factors are those external to the athlete's body, such as windsurfing exposure, training conditions, sports discipline specialization, sports equipment-related conditions, and environmental conditions. For example, participation in windsurfing often entails the unavoidable extrinsic hazard risk of exposure to high levels of solar radiation.[62] Hot, humid weather should be recognized as carrying the potential threat of hyperthermia and dehydration and, therefore, serious injury to windsurfers. Cold weather requires alertness to the possibility of hypothermia. Also. the use of hired windsurfing equipment may be a potential extrinsic risk

factor. It is not clear whether it is the equipment per se, its maintenance, or the athletes who use rental equipment that make rental equipment a risk factor. Nevertheless, *equipment-related risks,* such as the wetsuits, personal floating device, rig (mast, sail, and boom), universal joint, and board, should be checked regularly for worn and damaged parts before sailing. Windsurfers, therefore, should be knowledgeable about choosing the appropriate board and sail size according to their physical conditions and abilities.[4] Both modifiable and non-modifiable intrinsic and extrinsic risk factors for recreational windsurfers should be addressed. *Modifiable* risk factors refer to those that have the potential to be altered by appropriate prevention strategies. Different types of behaviour relate to injury risk factors and mechanisms in other sports.[63] The association between drowning and ethanol consumption before windsurfing has been documented.[10] As such, modifiable intrinsic *risk-taking behaviours* should be addressed. Of the four different behavioural types of recreational windsurfers; occasional and social windsurfers prefer middle wind (4-7 m/s), whereas competitive and pleasure windsurfers prefer strong wind (8 m/s and over).[22] The injury epidemiology of these four behavioural types of recreational windsurfers is unknown. The negative impact of inadequate nutrition and hydration may cause fatigue and exercise-associated hyperthermia in windsurfers. Also, modifiable *previous injuries* with inadequate rehabilitation should be managed with exercise interventions. Nonmodifiable intrinsic risk factors such as epilepsy attacks[45] and heart attacks[10,46] may cause potential submersion injuries or death during windsurfing and should be screened and disqualified.

Since windsurfing is a high-speed, exhilarating sport, it is not without the physical risk[15] of acute windsurfing-related injuries. Several identified injury patterns in recreational windsurfing differ substantially in their injury causes and mechanisms. According to a retrospective study, direct injuries from windsurfing equipment resulted in 64.5% of all 339 acute injuries: 17.2% from the boom, 16.7% from the foot straps, 12.7% from the mast, 8.7% from the board, and 8.1% from the fin.[7] Understanding mechanisms is a key component of preventing injuries in windsurfing.[47] Identifying the most frequent windsurfing-related injury mechanisms will lead to recommendations for protective gear.[7]

Strengths and limitations

According to my knowledge, this is the first review summarizing the injury epidemiological characteristics, such as a summary of the frequency of anatomical distributions of windsurfing-related injuries and a summary of multiple existing and potential risk factors among recreational windsurfers. The proposed standardization definitions of general windsurfing-related injuries and injury severity classifications and levels can be adapted to other sports. However, this study has several limitations. Other electronic databases were not searched; relevant and important data could be missed. There is a single author and article selection bias; information extraction was also done subjectively. The limited data on standardized injury epidemiology, such as evidence-based risk and predictor variables of windsurfing-related injuries, does not permit an empirically based list of suggestions for injury prevention.

Conclusions

There is inconsistency in the epidemiological methods and definitions of windsurfing research. The injury rates remain difficult to compare among studies. The findings in this review provide sports medicine researchers, including sports chiropractors, with a practical overview for further studies on the epidemiology of windsurfing-related acute injuries. Future studies should examine the significance and modifiability of both the existing and potential intrinsic and extrinsic risk factors for windsurfing injury epidemiology. The proposed standardization of definitions of general windsurfing-related injury terminologies and injury severity classifications and levels for windsurfing can be adapted to other sports for injury epidemiology. Understanding windsurfing-related injury rates, risk factors, patterns, causes, and mechanisms allows future studies to investigate and develop potential risk mitigation and/or prevention strategies. Future in-depth recreational windsurfing-related injury studies should focus on prospective designs using standardized injury epidemiological methods and definitions.

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Recreational windsurfing-related acute injuries: a narrative review. Part 2: injury prevention and a proposal for a set of potential prevention strategies with a holistic approach

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Objective: *The purpose of this review was to identify existing prevention strategies for recreational windsurfing-related acute injuries and provide clinicians with a practical overview of current evidence supporting proposed potential prevention strategies.*

Methods: *A literature search was conducted through March 8, 2023, using relevant keywords with Boolean operators, such as "windsurfing" AND "injury prevention" and "windsurfing" AND "exercise interventions," from the PubMed and Google Scholar databases. Only peer-reviewed English-articles were included.*

Results: *Existing prevention strategies, right-of-way rules, a new proposed set of eight potential primary to tertiary prevention strategies for windsurfing-related acute injuries, and proposed definitions of injury*

Blessures aiguës liées à la pratique récréative de la planche à voile: une étude narrative. Partie 2: prévention des blessures et proposition d'un ensemble de stratégies de prévention potentielles avec une approche holistique

Objectif: *Le but de cette étude était d'identifier les stratégies de prévention existantes pour les blessures aiguës liées à la pratique récréative de la planche à voile et de fournir aux cliniciens une vue d'ensemble pratique des preuves actuelles soutenant les stratégies de prévention potentielles proposées.*

Méthodologie: *Une recherche documentaire a été effectuée jusqu'au 8 mars 2023, en utilisant des mots clés pertinents avec des opérateurs booléens, tels que "windsurfing" AND "injury prevention" (planche à voile ET prévention des blessures) et "windsurfing" AND "exercise interventions » (planche à voile ET prescriptions d'exercices) à partir des bases de données PubMed et Google Scholar. Seuls les articles en anglais examinés par des pairs ont été retenus.*

Résultats: *Les stratégies de prévention existantes, les règles de droit de passage, un nouvel ensemble proposé de huit stratégies potentielles de prévention primaire à tertiaire pour les blessures aiguës liées à la pratique*

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prevention levels equivalent to Haddon's matrix were identified and tabled.

Conclusions: *The proposed potential prevention strategies may facilitate clinicians in preventing recreational windsurfing-related acute injuries. Injury prevention for recreational windsurfing is under-researched. Future studies should focus on large prospective clinical trials evaluating the efficacy of prevention strategies for recreational windsurfing-related injuries.*

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KEY WORDS: chiropractic, equipment safety, exercise interventions, exercise prescription, exercise training and conditioning, injury prevention, preparticipation screening, protective gear, rehabilitation, return to play, sports behaviour, sports nutrition, windsurfing.

de la planche à voile, et les définitions proposées des niveaux de prévention des blessures équivalentes à la matrice de Haddon ont été déterminés et présentés.

Conclusions: *Les stratégies de prévention potentielles proposées peuvent aider les cliniciens à prévenir les blessures aiguës liées à la pratique récréative de la planche à voile. La prévention des blessures liées à la pratique récréative de la planche à voile n'est pas suffisamment étudiée. Les études futures devraient se pencher sur de vastes essais cliniques prospectifs évaluant l'efficacité des stratégies de prévention des blessures liées à la pratique récréative de la planche à voile.*

(JCCA. 2023;67(2):159-174)

MOTS CLÉS : chiropratique, sécurité de l'équipement, interventions en matière d'exercices, prescription d'exercices, entraînement et conditionnement à l'exercice, prévention de blessures, dépistage avant la participation, équipement de protection, réadaptation, retour au jeu, comportement sportif, nutrition sportive, planche à voile.

Introduction

Prevention strategies for recreational windsurfing-related acute injuries have not been adequately addressed. When considering preventive measures, injury epidemiologists invoke one or more of the three main strategies: education, engineering, and enforcement.[1] A successful injury prevention program requires a multitude of sports medicine professionals, such as a sports chiropractor, who can play a role in promoting injury prevention and management of recreational windsurfing-related injuries.

Generally, prevention strategies are based on identified risk profiles, such as risk factors, causes, patterns, and mechanisms.[2-4] The data on epidemiological characteristics and the significant serious and catastrophic acute injuries among recreational windsurfers in Part 1 highlight the need for this review (Part 2) to identify existing prevention strategies. The burden of these injuries is potentially significant, but largely in light of the very little available data on hospital interventions. The limited evidence of the hospital burden of severe and devastating windsurfing-related acute injuries can be seen in a study of 22 windsurfers who required transportation to a tertiary hospital, prolonged hospitalization, severe disability, and two deaths.[5]

The purpose of Part 2 of this review was to identify existing prevention strategies for recreational windsurfing-related acute injuries and to provide clinicians with a practical overview of current evidence supporting proposed potential prevention strategies. A research question, "What are the existing prevention strategies for recreational windsurfing-related acute injuries?" was developed.

Methods

A literature search of the PubMed and Google Scholar electronic databases was conducted for existing prevention strategies from the study's inception until March 8, 2023. A manual search of reference lists from selected

articles was used to identify additional articles in the Google Scholar database. The grading systems A, B, and C of the "strength of recommendation taxonomy" (SORT)[6] were used to rate the evidence of prevention strategies for windsurfing-related acute injuries: A = consistent and good-quality patient-oriented evidence; B = inconsistent or limited-quality patient-oriented evidence; C = consensus, usual practice, opinion, disease-oriented evidence, or a case series.

Search strategy

To provide the most articles pertaining to the research question, the search method was broken down into several categories using Boolean operators and keywords such as "windsurfing" AND "injury prevention," "preparticipation screening" AND "windsurfing," "education" OR "technique" AND "windsurfing injuries," "behavior" AND "windsurfing injuries," "protective gear" AND "windsurfing injuries," "equipment safety" AND "windsurfing injuries," "technique modification" AND "windsurfing injuries," "nutrition" AND "windsurfing injuries," and "exercise interventions" AND "windsurfing injuries."

Inclusion and exclusion criteria

Articles were included if they were relevant to injury prevention strategies for recreational windsurfing-related acute injuries. Only peer-reviewed English articles were included. Articles were excluded if their contents were duplicated, ambiguous, or unavailable in English. Boat sailing, stand-up paddle-sailing, and kite-sailing were excluded.

Article selection

A PRISMA-type flow chart was used to provide information through the different phases of the study selection process of *identification*, *screening*, *eligibility*, and *inclusion* of citations. Articles were identified through a preliminary search. Duplications were removed. Articles were screened by title and abstract, assessed by full-text for eligibility, and finally included in the full-text review. Article screening, selection, and reviewing were done by the author exclusively.

Data extraction

Data were extracted, including the titles, authors, year of publications, study designs, number of participants, sample characteristics, interventions, and outcome measures if available. Articles were excluded if interventional data or preventive strategies were not available. To ensure accuracy and confirm that the data extraction of prevention strategies from each article reflected evidence towards the research question, any inconsistencies and limitations of the selected studies were assessed. The relevant data were extracted and compiled.

Results

The preliminary search identified 257 articles. This review included 37 citations in the final review from 82 publications assessed for eligibility (Figure 1). One study of sports chiropractic research collecting data on prevention strategies for nine elite women windsurfers was identified.[7] The existing prevention strategies for recreational windsurfing-related acute injuries were identified and summarized in Table 1. The overall SORT evidence rating of the existing prevention strategies was "C." Based on the identified injury characteristics, such as potential risk factors, causes, patterns, and mechanisms, of the Part 1 review and the relevant findings of selected articles in this Part 2 review, a new set of potential prevention strategies with supporting SORT evidence ratings for a holistic approach to recreational windsurfing-related injuries was identified, proposed, and summarized in Table 2. The overall SORT evidence rating of the proposed set of eight potential prevention strategies for windsurfing-related acute injuries was "C." The SORT evidence rating for prevention strategies for "*sport-specific exercise training and conditioning*" was "B" (Table 2). The proposed definitions of primary, secondary, and tertiary injury prevention and their equivalent relations to the original Haddon's matrix[8] for sports-related acute injuries were identified and compiled in Table 3. The windsurfing right-of-way rules (basic sailing rules, racing rules, and wavesailing rules) of the water to prevent collisions were identified and compiled in Table 4.

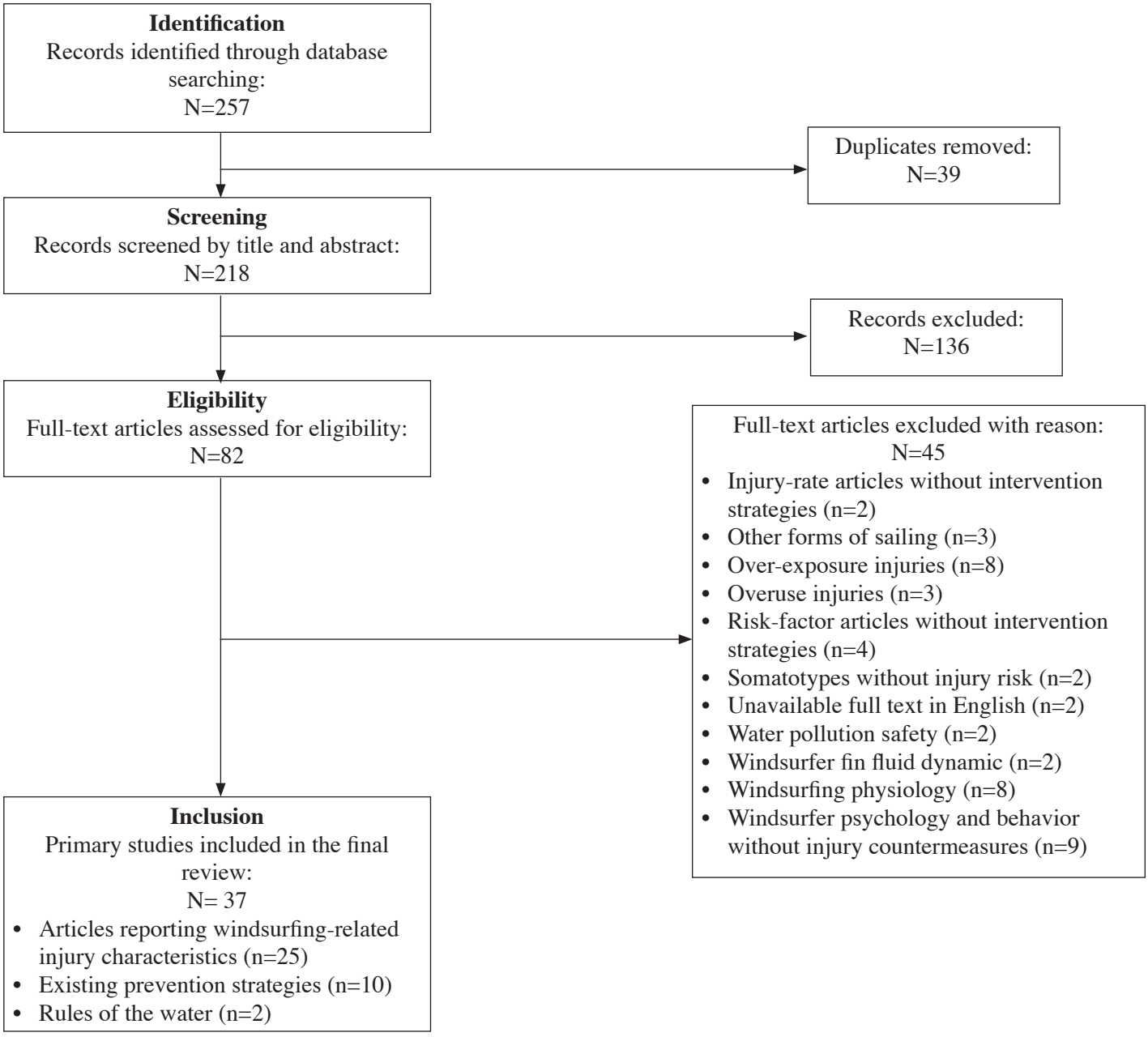

Figure 1.
Summary of a PRISMA-type flow chart of information through the different phases of the study selection process.

Table 1.
Summary of the existing prevention strategies for windsurfing-related acute injuries

Study	Study design	Total number of participants (n)	Existing windsurfing injury prevention strategies
Habal 1986 [22]	Descriptive study		• Obtain proper education (windsurfing) • Never sail alone into the high seas without several buddies • Avoid sailing in areas known to be inhabited by sharks • Protective gear: Wear a lifejacket, a wet or dry suit, a lightweight protective helmet, and a knee brace
Monahan 1986 [68]	Descriptive study		• Prepare for a weight training program, • Prepare for cardiovascular fitness training and conditioning • Warm-up and stretching • Maintain a good hydration • Apply sunscreen • Protective gear: Wear a wet or dry suit, a cap with a visor, a pair of high-protection sunglasses, and a neoprene windsurfing boot • Avoid sailing in offshore wind
McCormick and Davis 1988 [15]	Retrospective study (Survey questionnaire-interview)	n=73 (51 men, 22 women)	• Obtain preparticipation conditioning • Arrange a swimming test • Discourage windsurfing participation for athletes with epilepsy • Protective gear: Wear athletic sunglasses, limit continuous exposure, and wash with "artificial tear", wear a wet suit and protective gloves, and wear booties or shoes • Avoid strong wind and waves • Apply sunscreen at least 30 minutes before windsurfing • Review safety techniques in addition to windsurfing techniques
Nathanson and Reinert 1999 [20]	Retrospective study (Paper- & internet-based survey)	n=294 (90% men including 2 expert professionals)	• Modify fins with duller or softer edges and a shorter length • Modify a harness hook with a load equal to the windsurfer's body weight • Protective gear: Wear puncture-resistant footwear, a face mask, a personal floating device, and a helmet • Choose break-away foot straps
Woo 1997 [7]	Retrospective study (survey questionnaire & face-to-face interview)	n= 9 women (completed questionnaire)	• Sport-specific skills and conditioning (year-round) • Stretching and warm-up • Wear wetsuits, harnesses, and windsurfing athletic sunglasses • Apply sunscreen
Kalogeromitros et al., 2002 [5]	Retrospective study (Survey questionnaire)	n=22 (19 men, 3 women)	• Avoid food, alcohol, and other mind-altering drugs before windsurfing • Select the appropriate board according to the windsurfers' physical condition and abilities • Aware of sea sailing rules • Select a safe sailing area. • Avoid sailing alone at unknown venues • Avoid overpowering winds, busy waterways, and crowds of swimmers • Select foot straps with a releasing mechanism • Wear appropriate clothing (a wet suit) for protection from low-temperature environments
Rosenbaum and Dietz 2002 [24]	Descriptive study		• Apply a waterproof sunscreen • Protective gear: Wear protective gear (a helmet and a personal floating device), shatterproof sunglasses, neoprene booties or slippers, and gloves • Use equipment properly • Select foot straps with a fast-releasing mechanism • Follow the standard sailing rules • Sail with a buddy
Peterson et al., 2003 [33]	Retrospective study (Internet-based survey questionnaire)	n=327	• Protective gear: Wear a helmet • Choose the right board and sail size to prevent overpowering • A longer break after 60 minutes of windsurfing
Dysen et al., 2006 [37]	Retrospective study (Survey questionnaire)	n=107 (88 men, 19 women)	• Train to increase upper and lower body strength and maintain posture • Perform warm-up and stretching • Select a small-diameter boom • Protective gear: Wear a helmet, wet suit, and boots, a lumbar support belt, and an alternative harness • Select foot straps with a fast-releasing mechanism
Van Bergen et al., 2016 [30]	Retrospective study (Hospital records review & survey questionnaire)	n=18 (18 male completed questionnaire)	• Use smaller booms • Select quick-release foot straps • Prepare protective equipment, education, and counselling

The overall SORT evidence rating for the existing prevention strategies is "C." (A = consistent and good-quality patient-oriented evidence; B = inconsistent or limited-quality patient-oriented evidence; C = consensus, usual practice, opinion, disease-oriented evidence, or case series.)

Table 2.
Summary of a proposed set of potential strategies for windsurfing-related acute injuries with strength of recommendation taxonomy (SORT) evidence ratings

Proposed potential sports injury prevention strategies and aims (Individualized, holistic, and multidisciplinary approaches for the following potential eight prevention strategies)	**Sports injury prevention levels**	**SORT evidence ratings [6]**
1. Preparticipation screening: • To identify and disqualify conditions that may threaten potential injury or the safety of windsurfing (sports) participation • To identify potential modifiable musculoskeletal conditions such as previous injuries, muscle imbalance, and ligament hypermobility that require training, retraining, conditioning, and rehabilitation • To identify and disqualify non-modifiable medical conditions such as myocardial infarction and epilepsy that may cause a potential risk of drowning from attacks during windsurfing	Primary prevention	C
2. Preparatory education and technique considerations: • To provide appropriate preparatory education, such as the Beaufort scale and the rules of the water, and technique considerations such as windsurfing basic techniques and self-rescue techniques • To learn basic sports injury prevention strategies and potential risk factors • To learn basic windsurfing (sports) techniques • To learn basic sports nutritional strategies • To learn the basic principles of exercise training and conditioning	Primary prevention	C
3. Sports behavior modifications: • To access, address, and modify potential risk-taking sports behaviors • To identify and overcome barriers to behavior change and compliance	Primary prevention	C
4. Enforcement of protective gear: • To emphasize the need for wearing appropriate protective gear • To promote the need for protective gear enforcement	Primary prevention	C
5. Equipment safety and engineering modifications • To identify equipment-related risks • To improve and modify equipment design to reduce injury	Primary prevention	C
6. Technique modifications and skill development • To identify technique and skill incompetence • To optimize sport-specific physical fitness and sailing techniques • To correct and retrain poor technique, modify improper technique posture, and develop skill	Primary prevention	C
7. Sports nutrition considerations • *Sports nutrition screening, counseling, and guidance* ° To identify susceptible athletes with energy deficits and/or electrolyte disturbances ° To identify insufficient fluid consumption and alcohol consumption • *Preventive hydration and fluid replacement* ° To prevent hypohydration and exercise-associated dehydration, ° To prevent overhydration and exercise-associated hyponatremia ° To monitor fluid and electrolyte replacement	Primary prevention Primary and secondary prevention	C C
8. Sport-specific exercise interventions • *Exercise prescription (for athletes with or without sports-related injuries)* ° To prescribe personalized, self-directed, periodized exercise training and conditioning ° To identify training errors and prevent the risk of training-related injuries and overtraining ° To monitor training load and progression for effectiveness and determine any adverse effects • *Preparatory exercise training and conditioning* ° To help athletes increase muscle strength, power, endurance, etc, and reduce the chances of windsurfing-related (sports-related) injuries ° To enhance cardiorespiratory fitness • *Sport-specific exercise training and conditioning* ° To improve cardiorespiratory fitness ° To improve VO_2 max, aerobic, and anaerobic capacity, and lactic threshold. ° To improve muscle buffering capacity and the power of both upper and lower body muscles • *Sport-specific rehabilitation and return-to-sport* ° To identify suboptimal physiological and biomechanical conditions that should be adequately and specifically retrained, reconditioned, rehabilitated, and fully recovered. ° To prevent sports injuries or reinjury ° To ensure a safe return-to-training and a safe return-to-sport	Primary prevention Primary prevention Primary prevention Tertiary prevention	C C B C

The overall SORT evidence rating for the proposed set of potential prevention strategies is "**C.**" The SORT evidence rating for "Sport-specific exercise training and conditioning" is "B." (**A** = consistent and good-quality patient-oriented evidence; **B** = inconsistent or limited-quality patient-oriented evidence; **C** = consensus, usual practice, opinion, disease-oriented evidence, or case series.)

Table 3.
Proposed definitions of primary, secondary, and tertiary injury prevention and equivalent relation to the original Haddon's matrix for sports-related acute injuries

Definitions of sports injury prevention levels 1	Equivalent relation to the original Haddon's matrix 8
1. Primary injury prevention (risk factor prevention) is defined as the *prevention of the pre-event before the sports-related accident*, • using sports-related injury risk factors and sport-specific prevention strategies • by "identifying" risk factors and "removing" or "reducing" risk exposure to prevent the onset of the sports injury.	Pre-event (Before the accident)
2. Secondary injury prevention (preclinical prevention) is defined as the *prevention of the event during the sports-related accident*, • using preclinical prevention strategies by "screening" and "identifying" sports injuries in the earliest stages before the onset of signs and symptoms, and • by "ameliorating" the preclinical injury conditions through appropriate clinical tests, interventions, and/or sports-related modifications.	Event (During the accident)
3. Tertiary injury prevention (clinical prevention) is defined as the *prevention of the post-event after the sports-related accident*, • using clinical prevention strategies for the post-event • by "reducing" or "eliminating" the sequelae of the sports injury conditions through appropriate multidisciplinary sports rehabilitation and medical and/or other interventions to prevent longterm impairment and disabilities from injury, maximize the rehabilitation outcomes, or minimize and delay disabilities, and prevent reinjury.	Post-event (After the accident)

Adopted and modified from Press & Hagel 2005 [1] and Haddon 1972. [8]

Table 4.
The windsurfing right-of-way rules of the water to prevent collisions

Examples of the windsurfing right-of-way rules to prevent collisions
Basic sailing rules • To avoid busy waterways,[5] windsurfers must keep clear of swimmers, surfers, rowers, paddlers, and all other self-powered water users. • The overtaking board must keep clear[23] when overtaking a board, a sailboat, or a powerboat. • A windsurfer with right of way must *maintain his direction and speed*, while a windsurfer without right of way must keep clear and change directions to avoid collisions.[25] • A board riding towards the shore has right of way over one sailing out to sea.[23] Racing rules • *Tacking*: Any board in the process of *tacking* (turning the board through the eye of the wind) or *gybing* (turning the back of the board through the wind) must keep clear of boards not tacking or gybing.[23] • *Tacking*: While *tacking*, after a board passes head to wind, she shall keep clear of other boards until her sail has filled.[25] • *On the opposite tack (starboard tack over port tack)*: If two windsurfers are sailing towards each other from the *opposite* direction, the one on *starboard tack* (right shoulder closest to the mast) has right of way over the one on port *tack* (left shoulder closest to the mast).[23,25] • *On the same tack, overlapped (leeward over windward)*: If two windsurfers are sailing in the *same* direction, the *leeward* (side farther away from the wind) has right of way over the *windward* (side nearest to the wind).[23,25] • *On the same tack, not overlapped (clear ahead over clear astern):* when boards are on the same tack and not overlapped, a board *clear astern* shall keep clear of a board *clear ahead*.[25] • *Acquiring right of way*: when a board acquires the right of way, she shall initially give the other board room to clear, unless she acquires the right of way because of the other board's action.[25] • *Changing course*: when a right-of-way boat changes course, she shall give the other board room to clear.[25] Wavesailing rules • When two boards are riding the same wave, the board nearest the peak (breaking point of the wave) has the right of way.[23] • When two boards are riding different waves, the board furthest from the shore has the right of way.[23]

Adapted and modified from references.[5,23,25]
For details of windsurfing racing rules, please refer to "The racing rules of sailing, windsurfing fleet racing edition for 2021-2024.[25]

Discussion

This review found that the existing prevention strategies of the studies in Table 1 were inadequate, non-specific, and non-holistic. The suggested existing injury prevention measures were not strongly evidence-based but based on subjective data from participants from retrospective survey studies or from descriptive studies based on expert opinion. The identified injury prevention levels in Table 2 were mainly primary prevention (ten); the rest were primary/secondary prevention (one) and tertiary prevention (one). Notably, the eight prevention strategies listed below can be adapted to prevent athletic injuries in other sports. This review will discuss an overview of the proposed set of potential prevention strategies with supporting SORT evidence ratings for windsurfing-related acute injuries (Table 2). The SORT evidence rating for all the following preventative interventions is level C (except for sport-specific exercise training and conditioning, which is rated level B).

1. Preparticipation screening
2. Preparatory education and technique considerations
3. Sports behaviour modifications
4. Enforcement of protective gear
5. Equipment safety and engineering modifications
6. Technique modifications and skill development
7. Sports nutrition considerations
   - *Sport nutrition screening, counselling, and guidance*
   - *Preventive hydration and fluid replacement*
8. Sport-specific exercise interventions
   - *Exercise prescription*
     - *Monitoring of exercise prescription*
   - *Preparatory exercise training and conditioning*
   - *Sport-specific exercise training and conditioning*
   - *Sport-specific rehabilitation and return-to-sport*

1. Preparticipation screening

The major goal of preparticipation screening is to ensure the health and safety of the athletes.[9] Adopting a standardized process to conduct preparticipation physical examinations using available scientific evidence and best practices will help clinicians identify disqualifying conditions that may threaten the health and safety of participants.[10] Preparticipation screening may help prevent sports injuries[11] by identifying modifiable risk factors of potential neuromusculoskeletal deficits in recreational windsurfers like muscle imbalance[12] or asymmetries in strength and flexibility[13] and previous injuries[7] that require preparticipation sport-specific retraining and reconditioning, sport-specific rehabilitation, and a safe return-to-sport. Preparticipation screening may also identify and reduce the potential risk of drowning during windsurfing, which may be caused by nonmodifiable risk factors of medical conditions, such as heart attacks (myocardial infarctions,[14,15] palpitations,[16] and coronary artery disease[17]) and epilepsy attacks,[15,18,19] that warrant disqualification from windsurfing participation. To prevent sports-related sudden cardiac arrest, the Asian Pacific Society of Cardiology Consensus classifies sports according to the graded intensity of their static and dynamic components, such as windsurfing, as high-cardiovascular-intensity sports and recommends cardiovascular preparticipation screening.[17] Warning the identified epileptic windsurfers[20] about the hazard of a potential submersion injury or death and disqualifying them from windsurfing may help prevent such injuries. As such, preparticipation screening should be considered and implemented to reduce medical complications during recreational windsurfing.

2. Preparatory education and technique considerations

Professional instructional education for beginners in windsurfing is widely recognized as an effective strategy for preventing injuries.[21] Windsurfing injuries may not be easily avoided, and their prevention may not be through protective gear but through proper education.[22] Preparatory education may help novice recreational windsurfers learn the basics of windsurfing and basic injury prevention strategies to be aware of potential risks as well as their physical conditions and limitations. Properly accredited windsurfing education and technique training preparations are progressive; one cannot learn complicated maneuvers and sailing safety until one knows sailing theories, basic windsurfing techniques, the right-of-way rules of the water,[23] rescue techniques, and environmental sailing conditions are fully understood, and relevant techniques are competent.

A windsurfing board is considered a sailing vessel.[24] Windsurfers may be prone to accidents when certain basic rules of the water are violated.[5] A study found that 63% (14 out of 22) of windsurfers associated with severe acci-

dents were inexperienced, and 50% (9 out of 18) of windsurfers involved in severe accidents were unfamiliar with the basic rules of sailing vessels.[5] There are international maritime regulations designed to promote safety on the water, such as the "World Sailing" right-of-way rules to prevent collisions under the rules of windsurfing racing.[25] Windsurfers should be aware of sailing rules[5] and must comply with the right-of-way rules of the water (Table 4).

3. Sports behaviour modifications

Behaviour is the key factor in sports injury prevention.[26] An important step in the modified global model of the prevention sequence is assessing the compliance and risk-taking behaviour of a sports injury prevention strategy.[27] The risk-taking behaviour of windsurfers[5,28] highlights the need for sports behaviour modification. Avoiding habits of ingesting alcohol and other mind-altering drugs before sailing has been advocated.[5] However, barriers to behaviour change in injury prevention (e.g., inconvenience and perceived risk-benefit ratio) do exist.[29] Individual barriers to behavioural change and compliance should be identified and addressed. To overcome barriers, clinicians should consider sports behavioural evaluation and choose active over passive strategies, raising patients' awareness, and informing athletes of their individualized risks of predictable injury-prone circumstances.[29]

4. Enforcement of protective gear

Little is known about the efficacy of protective gear in the prevention of windsurfing-related acute injuries.[30] Studies found that only 20% of recreational windsurfers wear lifejackets,[31] and only 10% of recreational windsurfers[31] and 10% of elite professional windsurfers[32] use helmets to prevent head injuries. Another study found that 28.8% of 548 acute windsurfing injuries were caused by skidding falls;[33] hence, wearing preventive anti-skidding footwear should be considered. Protective gear must be worn when attempting jumps and loops,[31,32] as these maneuvers account for over 20% of all severe windsurfing-related injuries[31]. The burden of serious recreational windsurfing-related acute injuries highlights the need for enforcement of wearing appropriate protective gear, such as helmets [5,31,33] to prevent windsurfing-related head injuries. Enforcement of protective gear for windsurfing should be considered and implemented.

5. Equipment safety and engineering modifications

A recent epidemiological study reported that 28.8%, 5.1%, and 2.7% of 548 windsurfing-related injuries were caused by overpowered material, too strong surf, and material failure, respectively.[28] Windsurfers should therefore ensure that their own or hired equipment is well rigged and in safe, good condition,[23] and that they are knowledgeable about choosing the appropriate board and sail size according to their physical conditions and abilities,[5] as well as weather conditions. An improved design of windsurfing equipment may help prevent injuries.[20] It has been suggested that the development of breakaway foot straps may reduce the incidence of lower extremity injuries.[20,32,34] Fins with duller or softer edges and shorter lengths would likely reduce fin-induced lacerations[35] and fin-penetrating deaths[20]. Also, it has been proposed that a harness hook that disengages from the harness line at a load equal to the sailor's body weight could prevent catapult injuries.[20] Appropriate equipment safety and modification measures should be considered and implemented.

6. Technique modifications and skill development

Windsurfing technique is the ability to perform a correct maneuver, whereas skill is the ability to perform sport-specific maneuvers of different disciplines in the windsurfing competition setting. Technique and skill incompetence should be identified. A recent study found that 34.5% of windsurfing-related acute injuries were caused by the athlete's incompetence.[26] The main cause of freestyle acrobatic maneuver-related acute injuries was poor technique when performing forward and backward loops.[36] In general, windsurfing-related acute injuries may be triggered by fatigue interfering with the proper execution of maneuvers.[37] To prevent injury, a sport-specific skill is being able to choose and perform the right windsurfing techniques at the correct time. Modifying techniques have been considered the most effective way of minimizing or preventing injury.[37] Such modifications include improving lower body strength and body posture to aid optimal sailing technique and developing greater upper body strength to cope with the demands of pumping in the light winds with uphauling particularly in mind.[37] The correct windsurfing technique(s) retraining to maximize competence and/or modifications as well as skill development should be considered and implemented.

7. Sports nutrition considerations

Little is known about sports nutrition for preventing windsurfing-related injuries. However, general sports nutrition principles can be applied to windsurfing. Practical dietary strategies can be found in other non-water sports[38] or in aquatic sports[39-42] to reduce the risk of injury, prevent and treat injuries to muscles, bones, tendons, and ligaments, and improve training adaptations, dietary supplements, and nutrition for recovery.

Recreational windsurfers should have a basic knowledge of sports nutrition and hydration. Sufficient energy, macronutrient, and micronutrient intakes are critical to recreational windsurfing's physical demands and training goals. The results of the windsurfing energy demand study indicate that high demand is needed using both aerobic and anaerobic pathways, whatever the wind conditions.[43] There is limited information regarding dietary strategies for recreational windsurfers to support optimal training adaptations and prevent dehydration-related acute injuries[44] or heat-related illnesses[45].

7.1 Sports nutritional screening, counselling, and guidance

Sports nutritional screening[46] for diet quality[47] or nutrition status[48] and dietary counselling[47] for susceptible recreational windsurfers can be considered for injury prevention to monitor nutrition statuses, such as energy deficits and electrolyte disturbances. A study found that 22% (4 out of 18) of windsurfers ingested at least one unit of alcohol three hours before windsurfing.[5] Because of the association of water-related injuries such as drowning with ethanol consumption before sailing,[16] nutritional screenings should include hydration status and alcohol avoidance[46]. Sports dietitians may help guide and prevent dietary-related injuries in identified windsurfing athletes with glycogen depletion[47] and/or insufficient fluid consumption[48].

7.2 Preventive hydration and fluid replacement

Water replacement is an essential strategy in high temperatures and high humidity to prevent heat-related illnesses, such as heat cramps, heat exhaustion, and heat stroke.[39] To promote injury prevention, the potential risks of both hypohydration and hyperhydration on health and physical performance have been highlighted in the National Athletic Trainers' Association position statement.[49] Before sailing, windsurfers should consume enough fluids to prevent exercise-associated dehydration. According to the German Nutrition Society, fluid and electrolyte replacement must be considered after sport.[50] A recent review highlights the need for frequent breaks for hydration and careful monitoring.[45] The consensus statement of the Third International Exercise-associated Hyponatremia Conference concluded that fluid replacement (drinking according to thirst) should be educated to avoid hyperhydration due to overconsumption of hypotonic fluids (water or sports drinks) to prevent exercise-associated dehydration and life-threatening exercise-associated hyponatremia.[51,52] Nutritional education[48] for *primary* preventive hydration and *secondary prevention* through fluid replacement should be considered and implemented.

8. Sport-specific exercise interventions

A recent systematic review and meta-analysis found that exercise-based interventions were effective in improving functional movement pattern capability in untrained populations.[53] Exercises such as plyometric and neuromuscular training that help develop neuromuscular control and functional joint stability are critical in conditioning and rehabilitation programs designed for injury prevention in sports.[54] Also, systematic reviews provide convincing evidence that multimodal neuromuscular training can be effective for preventing sports injuries in both young and adult athletes.[55-57] Exercise prescriptions for athletic injuries and rehabilitation should be sport-specific. As such, clinicians should consider personalized and integrative, periodized sport-specific exercise interventions for their patients. For information specific to windsurfing training,[12,58-60] please refer to the following "Sport-specific exercise training and conditioning" section.

8.1 Exercise prescription

Sport-specific exercise prescriptions can be provided in a clinical office setting or via telehealth and/or mobile-health-application (mHealth) settings. Providing exercise instructions using multimedia may improve adherence.[61] A customizable, open-source electronic health record embedded exercise application with digital and printable copies and integrated direct email and/or mHealth options for ease of remote tracking-log sharing with patients and clinicians has been developed to facilitate clinicians' individual standardized exercise prescrip-

tion and to overcome patient adherence and accessibility barriers.[62] Personalized, integrative, self-directed, periodized, home-based prescriptions, including cross-training through the clinical office, telehealth, and mHealth settings, should be consistent with individual sport-specific physical demands, as well as the level of individual physical fitness conditions, cardiorespiratory fitness conditions, and neuromuscular control-balance-coordination conditions. Windsurfing's sport-specific demands can be simulated using easily available, low-cost, low-tech, home-based exercise equipment such as a heavy resistance tube, a suspension trainer, a hurdle ladder, gym rings, a gym ball, a balance board, and a plyometric jump box. Also, patients should be involved in personal goal setting, leading to individualization and goal-specific exercise prescription, which can improve motivation and compliance.[62]

8.1.1 Monitoring of exercise prescription

To assess the effectiveness and determine any adverse effects, athletic training load, progression of exercise prescription, and fatigue should be monitored for pain, perceived fatigue, strength, and ability to perform exercise and function.[63] The association between training loads and training-related injury risk is established.[64] A systematic review concluded that individual characteristics, such as fitness, body composition, injury history, and age, have a significant impact on the intended training load placed on athletes.[63] Monitoring the prescribed training load for injury prevention is to screen for those at increased risk of injury so that the prescribed training load can be adjusted to minimize these risks.[64]

The patient should be advised to monitor his or her progressive exercise responses, including training-associated pain or fatigue, heart rate, perceived exertion ratings, and blood pressure. Importantly, individualized oral and written exercise prescriptions should be given timely feedback on the volume, intensity, and density of the prescribed exercise training and monitored appropriately to identify improper training and prevent the risk of training-related injuries. To prevent the overtraining syndrome, it is important to correct identified training errors with strategies, such as appropriate periodization, adequate sleep, and sports nutrition for training recovery,[65] despite the absence of validated diagnostic tests and preventive measures[66].

8.2 Preparatory exercise training and conditioning

Windsurfing under strong winds requires isometric contraction of the core, upper body, and lower body muscles. Under light and moderate winds, the windsurfer "pumps" the sail rhythmically as a wing by providing the board with additional forward motion.[58] Preparatory exercise training and conditioning programs for the core and bilateral upper body and lower body[12] are essential for windsurfing practices, such as holding the boom, controlling the board, maintaining balance, and performing sail-pumping, and may delay fatigue and thus help prevent injuries. Traditionally, recreational windsurfers lack preparatory exercise training and conditioning,[67] according to most studies in Table 1. As such, recreational windsurfers should prepare a weight-training, cardiovascular fitness, and conditioning program.[16,21,68] Electromyographic pumping studies during simulated windsurfing on-shore[69] and sailing on-water[69] indicated that the main muscles are the trapezius, flexor carpi ulnaris, extensor carpi radialis, biceps brachii, gluteus maximus, and tibialis anterior[69,70]. It is important to include neuromuscular training[54] into traditional exercise training and conditioning. A reasonable amount of physical training should be recommended for musculoskeletal injury prevention.[71]

8.3 Sport-specific exercise training and conditioning

Windsurfing is a high-intensity endurance sport that requires very high aerobic and anaerobic capacities; the intensity of windsurfing is comparable to other endurance sporting activities like cycling, running, or cross-country skiing.[72] Windsurfing-specific strength training may enhance the anaerobic power and capacity of the arm, the leg, or both.[73] Onshore, periodized sport-specific strength training and conditioning, and sport-specific proprioception and neuromuscular training[54,55,57,74] using a similar windsurfing ergometer or windsurfing simulator,[59,75] if available, should be considered. Sport-specific functional training for windsurfers includes core muscles and balance. For example, windsurfing-specific abdominal core training may help with dynamic and static balance[76] and may reduce the risk of injury. Proprioception training, for example, is effective in reducing the risk of ankle sprains.[77] If a windsurfing simulator is not available, sport-specific balance and proprioception training programs such as ankle balancing and proprioception training using an easily available wobble board simulat-

ing the surfing board may help reduce the risk of acute ankle injuries.

Little is known about the relationship between exercise training and the anaerobic lactic acid (glycolysis) and alactic (phosphagen) systems, as well as the aerobic system. High-intensity interval training (HIIT) is characterized by bouts of high-intensity exercise interspersed with active or passive rest periods and can be further sub-categorized into low- and high-volume HIIT and sprint interval training (SIT)[78] above the lactate threshold to improve VO_2max, aerobic and anaerobic capacity, and performance.[79] Windsurfing training regimes should aim at enhancing the athlete's maximal aerobic capacity, the lactic threshold, and the power of both upper and lower body muscles.[80] To prepare for the physical and cardiovascular demands of different sailing techniques, sport-specific strength training programs for improving strength, anaerobic power, endurance, and muscle balance of the lower body and upper body,[12] as well as windsurfing-specific training programs for improving high-intensity cardiovascular demands, such as HIIT[58] or SIT[60] and moderate-intensity continuous training (MICT), should be considered. On-shore, HIIT, SIT, and MICT training can be practiced with improvised windsurfing-specific equipment such as a windsurfing ergometer for pumping[81] or a rowing ergometer that closely mimics explosive sail-pumping and engages both upper and lower body muscles[80] with rest intervals that have been advocated to minimize the risk of acute injuries[58]. On-water, audio real-time feedback coaching with the use of a smartphone in sailing training has the potential to help less experienced windsurfers.[82] Based on the evidence of systematic reviews and meta-analysis of HIIT[78] and SIT[79,83] in other sports, and the evidence of windsurfing training studies,[12,58-60,75,80] including HIIT[58] and SIT,[60] the SORT evidence rating for "*sport-specific exercise training and conditioning*" is "B."

8.4 Sport-specific rehabilitation and return-to-sport

Physical training, conditioning, and rehabilitation[54] and sport-specific functional tests should be considered for sport-specific demands to facilitate a safe return-to-sport. When athletes are injured, physical attributes, such as muscular strength, power, endurance, flexibility, balance, proprioception, speed, agility, and functional movement patterns, are less than optimal; a return to full recreational sports requires a nearly complete return of these physical components.[84] Athletes should be aware of the relevance of adequate treatment and rehabilitation after injury to avoid the recurrence of injuries.[71] Identified suboptimal conditions of these physical components should be adequately and specifically retrained, reconditioned, rehabilitated, and functionally recovered. A multidisciplinary team is often required to better treat and rehab an athlete and permit a prompt return-to-sport.[85] Several physical tests are used in sports rehabilitation to measure strength and power, such as the isometric maximal voluntary contraction tests, the one-repetition maximum tests, and other tests that target the upper and lower limbs.[86] Despite the lack of a "gold standard" in sports testing[87] and the limited evidence of functional movement screening for injury prediction,[88] functional performance tests using a windsurfing simulator[89] can help determine when an athlete can safely return to unrestricted activities[84].

The key goal of sport-specific rehabilitation protocols is *tertiary* injury prevention. When to return to windsurfing safely after injury is a complex and multifactorial decision that should be personalized. The return-to-sport clearance looks throughout the continuum of healing to determine readiness for sport.[87] There are five phases of the return-to-sport clearance continuum: repair, recovery, reconditioning, performance, and return-to-training.[87] According to studies, the average time for windsurfing-related moderate foot and leg injuries to return-to-training was 25.2 days,[90] and the average time for moderate injuries to return-to-sport was five weeks[30]. Importantly, personalized functional progression along the rehabilitation continuum and stages from the acute phase to reconditioning and return-to-sport should be based on functional criteria with sport-specific functional testing(s) and psychological readiness and not on time-based average return-to-training and return-to-sport data in the literature. Until return-to-training and return-to-sport rehabilitation protocols are met and completed to prevent injury or re-injury, only a gradual, personalized, and safe return-to-sport should be considered.

Strengths and limitations

According to my knowledge, this is the first study in which levels and definitions of injury prevention are suggested for windsurfing injuries, and a holistic set of eight potential injury prevention strategies (mainly primary preven-

tion) for recreational windsurfers is proposed with current evidence. The SORT evidence grading systems are used to rate the potential prevention strategies for windsurfing-related acute injuries. Practically, the proposed potential prevention strategies can be modified and adapted to prevent athletic injuries in other sports. However, this study has several limitations. Other electronic databases were not searched. Relevant and important data could be missed. There is a single author and article selection bias; information extraction was also done subjectively. The findings were limited by the inherent methodology of narrative literature reviews, such as the purely descriptive nature of the review and the inability to test any hypotheses about the relative effectiveness or ineffectiveness of the identified existing and proposed preventative measures. Only a brief overview of the current evidence-based prevention strategies is provided.

Conclusions

Injury prevention for recreational windsurfing is under-researched. The existing prevention strategies are inadequate, non-specific, and non-holistic. The proposed new set of eight primary to tertiary potential prevention strategies with supporting SORT evidence ratings and best practices for an individualized, holistic, and multidisciplinary approach may facilitate clinicians in mitigating risks and preventing recreational windsurfing-related acute injuries. Sports chiropractors can play a role in promoting a patient-oriented holistic approach to injury prevention and the management of windsurfing-related injuries. Future studies should focus on high-quality, large prospective randomized clinical trials evaluating the effectiveness of prevention strategies for recreational windsurfing-related injuries.

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Chiropractic management of bilateral meralgia paresthetica: a case report

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Objective: *The purpose of this report is to describe the course of chiropractic care for an adult male experiencing persistent anterolateral thigh pain due to bilateral meralgia paresthetica.*

Clinical features: *A 40-year-old male U.S. Veteran was referred to chiropractic care for a two-year history of bilateral anterolateral thigh pain and paresthesia that worsened with inguinal pressure and hip extension activities.*

Intervention and outcomes: *A total of six chiropractic visits, including a combination of telehealth and in-person appointments, took place over a period of 10*

Prise en charge chiropratique de la méralgie paresthésique bilatérale : un rapport de cas

Objectif: *Le but de ce rapport est de décrire l'évolution des soins chiropratiques pour un homme adulte souffrant d'une douleur persistante à la cuisse antérolatérale due à une méralgie paresthésique bilatérale.*

Caractéristiques cliniques: *Un vétéran américain de 40 ans a été recommandé à la chiropratique pour une histoire de deux ans de douleur et de paresthésie antérolatérale bilatérale à la cuisse qui s'aggravait avec la pression inguinale et les activités d'extension de la hanche.*

Intervention et résultats: *Un total de six visites chiropratiques, comprenant une combinaison de rendez-vous par télémédecine et en personne, ont eu*

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The patient involved with this case report consented to publication and documentation of this consent was provided at the time of submission.

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weeks. Treatments included patient education, soft-tissue therapy, therapeutic exercise prescription, and spinal manipulation directed toward the lumbar spine. The patient's pain was reduced from a 6/10 rating to a 0/10, he was able to reengage in recreational activities without discomfort, and sustained improvement was reported.

Summary: *In this case, a trial of chiropractic care was associated with a resolution of the patient's bilateral meralgia paresthetica symptoms.*

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KEY WORDS: case report; meralgia paresthetica; chiropractic; telerehabilitation; manual therapies; therapy, manipulation

lieu sur une période de 10 semaines. Les traitements comprenaient l'éducation du patient, la thérapie des tissus mous, la prescription d'exercices thérapeutiques et la manipulation de la colonne vertébrale lombaire. La douleur du patient est passée de 6/10 à 0/10, il a pu reprendre ses activités récréatives sans gêne et une amélioration durable a été constatée.

Résumé: *Dans ce cas, un essai de soins chiropratiques a été associé à une résolution des symptômes de la méralgie paresthésique bilatérale du patient.*

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MOTS CLÉS : rapport de cas méralgie paresthésique; chiropratique; téléréadaptation; thérapies manuelles; thérapie, manipulation

Introduction

Meralgia paresthetica is a peripheral neuropathy characterized by pain in the anterolateral thigh region.[1,2] This condition is a mononeuropathy involving the lateral femoral cutaneous nerve (LFCN). The LFCN is a peripheral nerve originating from the L2 and L3 lumbar nerve roots that travels under the inguinal ligament, approximately 1-2 cm medial to the anterior superior iliac spine (ASIS), as it exits the pelvis to supply sensory innervation of the anterolateral thigh (Figure 1).[3] Patients with meralgia paresthetica characteristically experience a superficial discomfort described as pain, numbness, burning, or stinging localized to the region supplied by the LFCN (Figure 2).[1] Meralgia paresthetica may develop at any age, but is most commonly diagnosed between the ages of 30 to 60[4,5], and there is no clear predilection for race or sex[4,6].

The etiology of meralgia paresthetica is widely variable, but it is most commonly reported to develop following irritation or entrapment of the LFCN. This condition is often described to be more common during pregnancy, among individuals with obesity, or following compression of the inguinal region from tight-fitting belts, clothing, or harnesses.[7,8] Iatrogenic causes of meralgia paresthetica have also been reported as a complication following a variety of surgical procedures, such as: appendectomy[9], hernia repair[10], or posterior thoracolumbar spine surgery[11,12]. Meralgia paresthetica has also been shown to be more likely in patients who have carpal tunnel syndrome and diabetes mellitus,[4,8] which is suggestive of a systemic susceptibility to neuropathic pain as a contributing factor to the development of this condition.

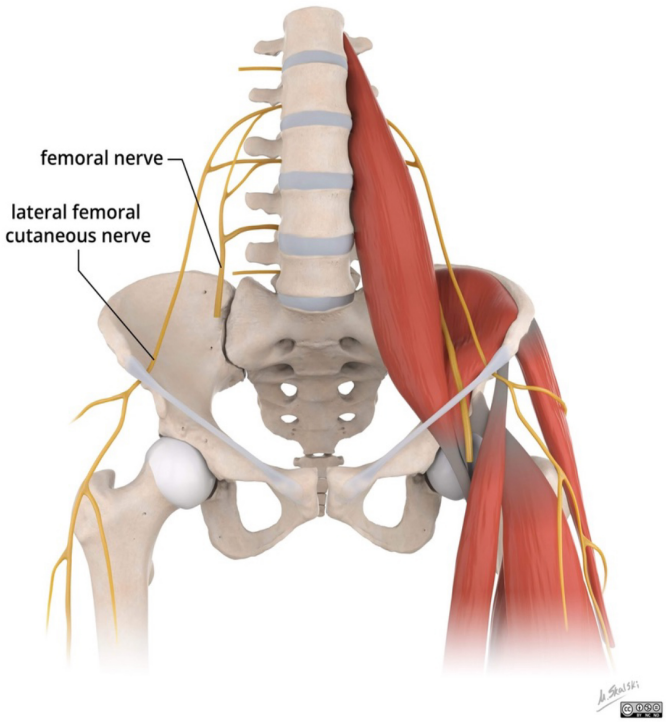


Figure 1.
Course of the lateral femoral cutaneous nerve

Figure 2.
Sensory distribution of the lateral femoral cutaneous nerve

While a variety of treatments are reported to help patients recover from meralgia paresthetica, there is an absence of controlled trials investigating this topic.[13] Recommendations often begin with reassuring patients that most cases spontaneously resolve[13,14], along with identifying and removing any cause of compression near the inguinal region, which may occur with tight clothing or ill-fitting belts or harnesses[6]. Conservative forms of treatment are also recommended as part of the initial management strategy for meralgia paresthetica, but little exists describing details involved with these conservative treatment approaches.[1,13] The purpose of this report is to describe the course of chiropractic care for an adult male experiencing persistent anterolateral thigh pain due to bilateral meralgia paresthetica.

Case presentation

A 40-year-old Caucasian male U.S. Veteran sought care with his primary care provider (PCP). During this encounter he reported bilateral "sensitivity and tenderness" on both of his anterolateral thigh regions, which had persisted for the proceeding two years and was becoming "very bothersome." He explained that his discomfort initially began without any associated injury or trauma and had remained unchanged after attempting to manage the condition with over-the-counter acetaminophen and a trial of physical therapy over the proceeding four months. Additional diagnoses associated with this primary care visit were irritable bowel syndrome and psychological stress. The PCP's assessment involved a "suspected lateral femoral cutaneous nerve syndrome or possible lumbar nerve root disorder" and treatment included wearing loose-fitting clothing, continued aerobic exercise, and attempting another form of conservative care. The Veteran expressed a desire to try chiropractic care for his condition and a referral to the VA's chiropractic clinic was placed.

The chiropractic consultation was performed three days after the PCP referral and this appointment was scheduled as a virtual video telehealth visit, per the Veteran's preference. During this consultation, the patient explained how he requested chiropractic care to address his bilateral thigh pain and numbness, but also explained having a four-to-six-month history of "mild lower back stiffness." A thorough health history was performed during the consultation, and he described the character of his bilateral thigh pain as a "constant numbness and tingling" (i.e., paresthesia) on the left anterolateral thigh along with "intermittent and less intense" symptoms on the corresponding region of his right thigh. He reported that his characteristic paresthesia progressed to an intense "burning" sensation following direct pressure to the inguinal regions, about 1.0 cm medial to the anterior superior iliac spine (ASIS) landmark. He explained how engaging in recreational aerial yoga activities also flared this burning pain when the suspension straps placed pressure on his superior thigh and inguinal regions. His paresthesia was also worsened while lying supine or with hip extension activities, but relieved while in a seated position. He denied any symptoms in the posterior thigh regions, lower legs, or feet. He also explained that his low back "stiffness" was isolated to the axial lumbosacral region, and he attributed this to a recent increase in time spent sitting over the previous months, since he was nearing the end of his Ph.D. program and had been busy preparing his dissertation defense. Outcome measures were also collected during the telehealth consult by

displaying the questionnaires on the screen and recording the patient's verbal responses (Table 1). Baseline outcome measures included the PEG-3 Pain Screening tool,[15] the range of his pain experience at its "best" and "worst" on a Numerical Pain Rating scale, a Patient Specific Functional Scale[16], and the Self-Completed Leeds Assessment of Neuropathic Symptoms and Signs (S-LANSS) questionnaire was also used to help evaluate the potentially neuropathic nature of this patient's thigh pain[17,18]. Near the end of the virtual chiropractic consult, the diagnosis of meralgia paresthetica was communicated and he was scheduled for an in-person follow-up.

Table 1.
Baseline outcome measures from the initial chiropractic consultation

PEG Questionnaire	
Average pain intensity	6/10
Interference with enjoyment of life	5/10
Interference with general activity	1/10
PEG score (mean of all 3 categories)	4/10
Range of Pain (via NPRS)	
Pain at its best	2/10
Pain at its worst	8/10
PSFS	
Aerial yoga	2/10
Sleep	4/10
S-LANSS Neuropathic Pain Questionnaire	
score	21/24

PEG; an outcome measure whereas the title is an acronym emerging from its components: pain intensity (P), interference with enjoyment of life (E), and interference with general activity (G), scores range from 0-10, higher scores are more severe.
NPRS; Numerical Pain Rating Scale, 0 = "no pain" and 10 = "worst pain imaginable".
PSFS; Patient Specific Functional Scale, 0 = "unable to perform" and 10 = "Able to perform at the same level as before injury or problem"
S-LANSS; Self-Completed Leeds Assessment of Neuropathic Symptoms and Signs, higher scores suggest pain of neuropathic origin.

A physical exam was performed at the first in-person appointment and included the anterolateral thigh and lumbosacral regions. No changes in tissue appearance or evidence of inflammation were visualized, his gait was normal, hip ranges of motion were normal, and a mild reduction of lumbar extension range of motion was observed while standing. Deep palpation applied to the soft tissues of the anterior pelvic regions, approximately 1.0 cm medial to each ASIS, reproduced his characteristic anterolateral thigh pain and paresthesia. Sensory testing also revealed a mild reduction in light touch on each anterolateral thigh, corresponding to the sensory distribution of the lateral femoral cutaneous nerve (Figure 2). The remainder of the lower extremity neurological exam was within normal limits, including patellar and Achilles tendon reflexes, bilateral negative femoral nerve tension tests, and bilateral negative straight leg raise tests. He describes his low back pain as being isolated to the axial lumbosacral junction and the associated lower lumbar paraspinal musculature. He denied any tenderness with palpation or percussion of the lumbosacral or lateral hip regions but did have a mild increase in low back pain during the lumbar extension-rotation test (i.e., Kemp test). No directional preferences were found to centralize or peripheralize his low back pain complaint. After completion of the physical exam, it was determined that no special studies were needed. The differential diagnosis of an upper lumbar disc disorder was ruled out and the clinical diagnosis of meralgia paresthetica was made along with a diagnosis of low back pain, likely of facetogenic nature.[19]

Treatment began at his first in-person appointment and included a combination of patient education, self-care recommendations, at home exercises, lumbosacral spinal manipulation, and various forms of soft-tissue therapy. Patient education involved reassurance that this condition is often self-limiting,[20] we reviewed the course of the lateral femoral cutaneous nerve, and we outlined common causes of irritation known to provoke his condition. Self-care recommendations included prioritizing stress management techniques, ensuring proper sleep, eating a healthy diet, and maintaining regular physical activity; these recommendations were based off the main pillars of Lifestyle Medicine.[21] The recommended home exercise program focused on lumbopelvic mobility and conditioning activities outlined in Table 2 and Figure 3. These exercises were demonstrated at the first in-person treatment session and provided to the patient via email using the Home Exercise Program Builder (MedBridge, Bellevue, WA). Spinal manipulative therapy (SMT) involved a

lumbosacral high-velocity, low-amplitude technique performed in a side-lying position (Figure 4).[22] Soft-tissue therapies were directed toward the superior portions of the rectus femoris, sartorius, and tensor fasciae latae musculature as well as the iliotibial tract (i.e., IT band); these included pin-and-stretch (Figure 5), VibraCussor massager (IMPACT Inc., Salem, OR) and a TigerTail muscle rolling stick (Tiger Tail USA, Kent, WA) (Figure 6).

Table 2.
Recommended home exercise program

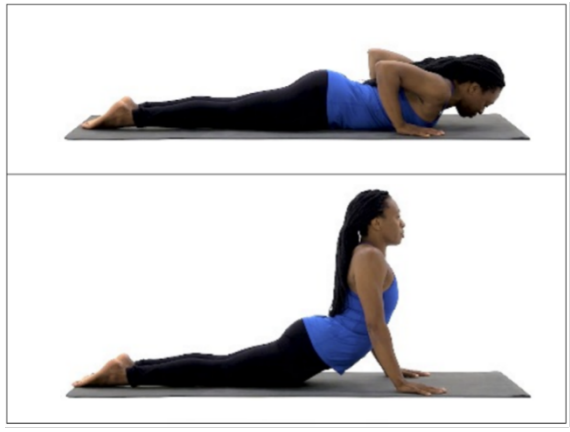
HEP Activities*	Instructions
Standard lunge	15-20 repetitions with each leg
Walking forward lunge	15-20 repetitions with each leg
Lateral lunge	10 repetitions with each leg
Cobra pose	6-8 repetitions with gradually increasing extension
Supine bridge	20 repetitions with slow movements
Side plank with clam	3-10 repetitions with each leg
Supine quadriceps stretch with a stretch strap	Hold for 15-30 seconds
Lateral shifts on wall	10-20 repetition in each direction

HEP; home exercise program
*The patient was instructed to perform each of these activities at least four times per day and no more than once every waking hour. He was also instructed to stop performing any activities that caused his pain to flare or if he experienced progressive worsening of his neurologic symptoms.

Figure 3.
Recommended home exercises

A. Standard lunge

B. Lateral lunge



C. Cobra pose

D. Supine bridge

E. Side plank with clam

F. Supine quadriceps stretch (with Strap)

Figure 4.
Lumbosacral spinal manipulative therapy technique (this image is for demonstration purposes and does not include the patient involved in this report).

In-person treatments consisted of a series of four total treatments over a period of eight-weeks. During the first treatment, he denied any adverse events or pain flares throughout care. At his second appointment, he described a reduction of his pain from his characteristic intense numbness and burning sensations to a sensation akin to a "mild sunburn." He reported regularly engaging with his recommended self-care and home exercises and explained that he had also incorporated his own hip mobility activities and began walking 20 to 30 minutes, each day. At his third appointment, he reported continued improvement, continuation with his self-care and exercise routine, and was happy to report that he had successfully defended his Ph.D. dissertation and had also secured a job in his chosen field. At the fourth treatment, he explained that his pain was "pretty much gone" and only had minor discomfort when pressing firmly near his ASIS regions. We discussed releasing him from his scheduled episode of care, but he

A. Starting position

B. Ending position

Figure 5.
Pin and stretch technique used in this case (these images are for demonstration purposes and do not include the patient involved in this report).

expressed a preference to schedule one additional video telehealth appointment to ensure his symptoms did not return. At this video telehealth follow-up, one month later, he reported sustained improvement, while explaining that he had been "feeling great" and his bilateral thigh pain and paresthesia was now "gone." When asked about his

Figure 6.
Soft-tissue roller applied to the vastus lateralis iliotibial tract region (this image is for demonstration purposes and does not include the patient involved in this report).

response to pressure near the ASIS region, he explained that "If I push hard on that area, it causes a minor tingling for a few seconds" but denied any pain or burning sensations. We agreed to release him from his scheduled trial of care but allowed him the option to schedule a follow-up as-needed, if his condition returned. Outcome measures were then collected during this video telehealth appointment (Table 3) and he reported that his condition was feeling "a great deal better" on the Patient's Global Impression of Change (PGIC) scale.[23] We also discussed submitting his case for publication and he provided enthusiastic consent and promptly signed and returned an emailed consent form.

Discussion

Meralgia paresthetica is an entrapment neuropathy involving the lateral femoral cutaneous nerve[24], which some say is "probably underrecognized"[25] at a reported incidence of 4.3 per 10,000 person years[4]. Meralgia paresthetica typically causes neuropathic pain on the anterolateral region of a single thigh, but has been reported to occur bilaterally in 10-20% of cases.[14,26,27] Uniquely, the famous psychoanalyst Sigmund Freud was credited as the first to report a case of bilateral meralgia paresthetica and dis-

Table 3.
Follow-up outcomes measures from the final appointment

PEG Questionnaire	
Average pain intensity	0/10
Interference with enjoyment of life	0/10
Interference with general activity	0/10
PEG score (mean of all 3 categories)	0/10
Range of Pain (via NPRS)	
Pain at its best	0/10
Pain at its worst	"0.5"/10
PSFS	
Aerial yoga	"9.5"/10
Sleep	10/10
PGIC Scale	
"A great deal better, and a considerable improvement that has made all the difference."	7

NPRS; Numerical Pain Rating Scale, 0 = "no pain" and 10 = "worst pain imaginable".
PSFS; Patient Specific Functional Scale, scores range from 0-10, lower scores are more severe.
PGIC; Patient's Global Impression of Change score, scores range from 1-7 with a 1 = "No change (or condition has got worse)" to a 7 = "A great deal better, and a considerable improvement that has made all the difference."

closed that he wrote the case about himself.[26,28] Cases of bilateral meralgia paresthetica are uncommon in the literature and we are not aware of any other reports or bilateral cases treated with chiropractic or other conservative management strategies.

Diagnosing patients with meralgia paresthetica may be a challenge for a variety of reasons. Meralgia paresthetica is a neurological disorder lacking objective or confirmatory diagnostic tests. This condition is identified as a "clinical diagnosis," wherein the clinician is required to recognize the features of meralgia paresthetica, consider alternative explanations, and determine that this diagnosis is the best explanation for the patient's presentation.[1] Unfortunately, the features of meralgia paresthetica are not uniformly recognized, and this under recognition has been thought to contribute to overlooked diagnosis.[4] We reviewed the literature for clinical exam procedures that may assist in the diagnosis of meralgia paresthetica and identified the pelvic compression test[29], the Tinel sign near the ASIS[30], and a side lying neurodynamic test[31]. While these orthopedic tests have been described, there is little in the way of evidence to quantify their clinical utility and clinicians should use them only as an adjunct to the neurologic exam when evaluating patients suspected of having meralgia paresthetica.

Differential diagnoses to consider when evaluating someone suspected of having meralgia paresthetica should include conditions that produce pain or sensory abnormalities in the anterolateral thigh region. A variety of other pathologies may produce sensory abnormalities in a distribution that mimics meralgia paresthetica. Reports of misdiagnoses confused to be meralgia paresthetica include: lung cancer metastasis to the iliac crest[32], uterine fibroids[33], avulsion fracture of the ASIS[34,35], appendicitis[36], and hypothyroidism[37]. Radiculopathy emerging from upper lumbar disc herniations have also been confused with meralgia paresthetica and should be considered within the list of differential diagnoses when evaluating someone suspected of having meralgia paresthetica.[38–40] Other musculoskeletal conditions reported to cause lateral thigh pain may also be considered, and include: greater trochanteric pain syndrome, trochanteric bursitis, and various femoroacetabular joint pathologies. Clinicians should also stay mindful that referred pain patterns involving the lateral thigh region are common in patients with chronic low back pain involving the lumbar facet joints, sacroiliac joints, and/or lumbar discs.[41] It is important to emphasize that patients demonstrating motor dysfunction, abnormal reflex tests, or sensory abnormality extending beyond the region supplied by the LFCN (Figure 2) should be further worked-up for other pathologies, as meralgia paresthetica does not manifest with such features.[1] While special studies are not required to establish the diagnosis of meralgia paresthetica, diagnostic ultrasound, MRI, or CT may be useful if soft-tissue or bony lesions are believed to be contributing to a patient's presentation. Electrodiagnostic testing may also be used[1], but these may be technically difficult due to reported variations in the course of the LFCN[3,42]. If clinical suspicion of serious pathology is sufficiently low, or there is an absence of severe or progressive symptoms, special studies may be delayed until a trial of conservative care has occurred.[13]

Treatment recommendations for meralgia paresthetica suggest conservative approaches as an appropriate initial

management strategy, combined with advice to avoid causes of external compressive forces near the inguinal region.[1,13] It is reported that the majority of patients with this conditions will respond to conservative measures[7], but there is considerable variability in what constitutes conservative care; forms of conservative care reported in the literature have included: reassurance of a favorable natural history, physiotherapy, manual therapies, acupuncture, non-steroidal anti-inflammatory medications, and even corticosteroid or anesthetic injections (i.e., nerve blocks)[1,13,31,43]. We reviewed the literature and identified three case reports describing chiropractic treatment for patients with meralgia paresthetica.[44–46] The first report was published in 1982 and involved a heel lift, electrotherapy to the lumbar musculature, and prone lumbar spinal manipulation "two to three times per week" for approximately five weeks, which resulted in a complete resolution of the patient's right-sided meralgia paresthetica pain.[44] The next report was published in 2006 and involved Active Release Technique (ART®) applied to a restricted sacroiliac joint as well as the iliopsoas and quadratus lumborum musculature, post-isometric relaxation stretching of the iliopsoas musculature, and lumbopelvic home exercises to encourage mobility and flexibility.[45] This approach resulted in 90% improvement of the patient's right-sided meralgia paresthetica symptoms following six treatments over a six-week period. The third report was published in 2012 and involved a form of applied kinesiology referred to as "injury recall technique" that applied manual forces to the rectus femoris musculature, sacroiliac spinal manipulation, prone pelvic blocking, and transverse friction massage to the region of the inguinal ligament and iliopsoas musculature.[46] This approach resulted in a 95% improvement in the patient's right-sided meralgia paresthetica symptoms following three treatments over a two-week period. These three case reports describe a high amount of variability in the methods used by chiropractors to manage meralgia paresthetica. Our hope is that this report will provide additional insight as to how chiropractors, or other conservative care providers, may address the work-up and treatment of patients with meralgia paresthetica.

Limitations

The nature of a case report comes with many limitations. Treatment was provided in an outpatient setting and a wide variety of uncontrolled factors may have influenced the patient's clinical features. The results of this case should also be considered in the context of the reportedly favorable natural history of meralgia paresthetica and in the context of the regression to the mean phenomenon, whereas unusual observations (e.g., high pain levels) are likely to be followed by less extreme observations. We would also like to emphasize the non-specific effects that manual therapy may have on an individual's experience of pain.[47] Additionally, chronic pain is a complex biopsychosocial phenomenon; this patient's pain experience and recovery likely involved factors that were unable to be captured in this report. One such factor that may have influenced his recovery is that he was defending a Ph.D. thesis, which likely increased his levels of stress or anxiety, and then accepted a job in his new career field near the end of this trail of care, which likely reduced his stress and anxiety. Ignoring the role that such psychosocial factors may have on his chronic pain experience would be short-sighted.[48]

Summary

This case describes a short course of chiropractic care for the management of a U.S. Veteran suffering from persistent bilateral meralgia paresthetica. In this case, treatment consisted of a combination of video telehealth visits, in-person manual therapies, a home exercise program, and self-care recommendations. Treatment was associated with a sustained resolution of this patient's bilateral meralgia paresthetica symptoms and a return to his normal work and recreational activities.

Acknowledgments

The authors would like to acknowledge the sacrifices that all U.S. Veterans and active-duty military personnel have made, and we thank them for their service. We have also utilized the capitalized honorific form of the term Veteran throughout this document, in accordance with the VA Style Guide.

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Partial mixed neuropathy of the fourth lumbar spinal nerve misdiagnosed as “shin splints.”

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A case of anteromedial leg pain diagnosed and treated for 10 years as “shin splints” (medial tibial stress syndrome) is described. A history and examination was performed focused on anatomy, biomechanics, and peripheral nerves. Detailed sensory testing was performed in the painful area, and imaging was obtained to confirm the diagnosis. The clinical investigation was consistent with dynamic stenosis of the left L4-5 intervertebral foramen, causing a mixed partial mononeuropathy of the L4 spinal nerve that presented as pain and hypersensitivity in the anteromedial shin. Manual therapy maneuvers intended to open the intervertebral foramen led to resolution of the pain and sensory deficits. After three additional treatments performed within a month, resolution was maintained for >3 years. This case highlights how concepts from

Neuropathie mixte partielle du quatrième nerf spinal lombaire diagnostiquée à tort comme une “périostite tibiale”.

On décrit un cas de douleur antéro-médiale de la jambe diagnostiquée et traitée pendant 10 ans comme une « périostite tibiale » (syndrome de stress tibial médial). L’anamnèse et l’examen ont porté sur l’anatomie, la biomécanique et les nerfs périphériques. Des tests sensoriels détaillés ont été effectués dans la zone douloureuse et une imagerie a été réalisée pour confirmer le diagnostic. L’examen clinique était compatible avec une sténose dynamique du foramen intervertébral gauche L4-5, provoquant une mononeuropathie partielle mixte du nerf spinal L4 qui s’est manifestée par une douleur et une hypersensibilité dans le tibia antéro-médial. Des manœuvres de thérapie manuelle visant à ouvrir le foramen intervertébral ont permis de résoudre la douleur et les déficits sensoriels. Après trois traitements supplémentaires effectués en l’espace d’un mois, la résolution s’est maintenue pendant trois ans. Ce cas montre comment les concepts issus des études précliniques, associés aux examens

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preclinical studies, coupled with basic anatomical, neurological, and biomechanical investigations, can be critical for accurate diagnosis and treatment for a case previously considered unresponsive to care.

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KEY WORDS: chronic pain, diagnosis, medial tibial stress syndrome, neuropathy, chiropractic

anatomiques, neurologiques et biomécaniques de base, peuvent s'avérer essentiels pour un diagnostic et un traitement précis d'un cas précédemment considéré comme ne répondant pas aux soins.

(JCCA. 2023;67(2):186-193)

MOTS CLÉS : douleur chronique, diagnostic, syndrome de stress tibial médial, neuropathie, chiropratique

Introduction

The term "peripheral neuropathy" has been defined as "a disturbance of function or pathological change in a nerve."[1] A peripheral neuropathy can be of any of the components of the peripheral nervous system, which includes the somatic nerves, the dorsal root ganglia, the dorsal and ventral roots, and the autonomic nerves and ganglia.[2,3] Patients with chronic peripheral neuropathies present clinically with a broad spectrum of symptoms that reflect the affected components of the injured nerve, and can include pain perceived in any structure, altered sensitivities for touch and temperature, and motor and sympathetic dysfunction. Often overlooked is that due to the length of the peripheral nerves, pathologies proximal to the symptoms can cause more distal symptoms. The uniqueness of this case is that the symptoms closely mimicked a medial tibial stress syndrome, while the pathology was 50 to 70 cm proximal to the symptomatic site.

Case presentation

A 23-year-old athletic woman presented with constant pain in her left anteromedial shin and intermittent lower back pain. The symptoms started 10 years previously, following participating in track and field events, particularly the long jump. She was diagnosed and treated as suffering from medial tibial stress syndrome, commonly referred to as "shin splints."[4,5] Medial tibial stress syndrome typically develops following heavy and prolonged exertion, is usually sports-related, and can cause periostitis, stress fractures, and possibly compartment syndrome. The patient had consulted numerous practitioners, including medical physicians, chiropractors, physical therapists, athletic trainers, and a nurse practitioner (Figure 1). X-rays and MRI had been obtained on the left leg and were unremarkable. Extensive treatments had been directed at the shin, and included exercises, deep massage, ice, heat, and electrical stimulation, none of which

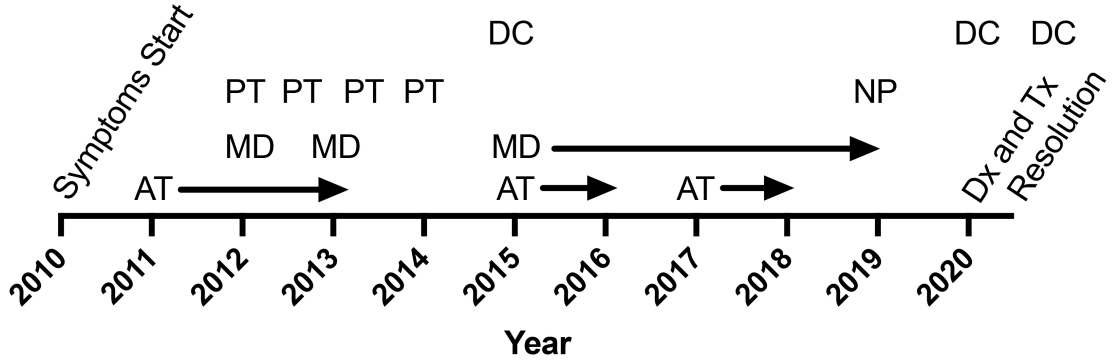

Figure 1.

Timeline of previous care. Each entry indicates a separate provider. AT = Athletic Trainer (High School, 2011-2013; College 2015-2017), MD = Medical Doctor, PT = Physical Therapist, DC = Doctor of Chiropractic, NP = Nurse Practitioner. The third MD cleared athletes for training and competition but did not otherwise provide care. Dx = Diagnosis, Tx = Treatment (by author).

led to more than transient symptomatic changes. The patient had also received care from a chiropractor, but did not mention the shin symptoms. Full-spine X-rays that were read by a radiologist were reported to show "questionable anterolisthesis of L5-S1" but no other structural abnormalities. The patient received 16 treatments that included lumbar spinal manipulation and manual therapy to the neck and upper back.

Over the previous five years, the patient had been a competitive pole vaulter, which had caused the pain to become intermittently more intense, despite continued care as described above. The patient reported sharp pain while in the launching phase of her vaults (when the left hip and lumbar spine were hyperextended). The only time that the patient reported being without pain was during a two-month hiatus from pole vaulting (one year prior to the current presentation). The pain was described as superficial burning and stabbing, and deep aching.

Examination

The patient was exceptionally physically fit and had no postural abnormalities or asymmetries. Lower limb motor power testing reflected the overall high fitness level of the patient and was otherwise unremarkable in that the symptoms were not provoked. There was no tenderness of the symptomatic leg's musculature or of the tibia as would be consistent with periostitis or stress fractures. Because the presenting complaints seemed consistent with a neuropathy of the terminal branch of the saphenous nerve, the entire path of the saphenous nerve was palpated, and was found to be unremarkable for tenderness or reproduction of symptoms. Active lumbar flexion increased back pain, but not leg pain. Active lumbar extension was limited, and provoked the leg symptoms and back pain. Supine unilateral knee and hip flexion (Thomas test) was not painful, but caused the contralateral leg to lift from the table consistent with iliopsoas tightness (bilaterally). Left sided active and passive straight leg raise tests reproduced the shin symptoms at 65° of hip flexion, but not when the hip was externally rotated. When ankle dorsiflexion or hip internal rotation were performed during the straight leg raise at 60° of hip flexion, the shin pain was also reproduced. Performed on the right leg, these tests were unremarkable. Upon prone examination, the paraspinal muscles were symmetrically very dense feeling but not tender, consistent with her high level of fitness, and prevented deeper skeletal structures from being specifically examined. The interspinous ligaments were tender between lumbar (L) and sacral (S) spinous processes of L3 – S1. The sacroiliac joints and gluteal musculature were unremarkable to examination. Prone passive knee flexion with hip extension, designed to traction the femoral nerve, reproduced the shin pain. This test was negative

Figure 2.
Sensory testing of the left anteromedial shin. The reported painful area is outlined. Black dots are where the 0.6 cN monofilament was reported to be painful. At the red dots, neither the 0.04 or 0.6 cN filaments were perceived, but the 2 cN filament was reported to be painful. See text for further details.

when performed on the right. Deep tendon reflexes were normal, there were no strength deficits, and there were no other cutaneous sensory alterations other than described next.

Because the presenting complaints and history seemed consistent with nerve involvement, sensory testing was performed, with the patient unable to see the testing procedure. The painful area was delineated with feedback from the patient using a cotton wisp, by lightly brushing from the surrounding areas until the patient stated that the sensation changed from light touch to pain (Figure 2). Sensory testing was then performed using nylon monofilaments exerting 0.04, 0.6, 2, and 6 cN (Semmes-Weinstein Touch-Test, Stoelting, US). The 0.04 filament was chosen because it was the least force that was consistently perceptible on the entire leg outside the dotted area. The 6 cN filament was the lowest force that evoked a report of being noxious outside the dotted area. At the black dots, the 0.6 cN filament was reported to be painful, and thus allodynic (painful at a stimulus level that was not normally painful). At the red dots, neither the 0.04 or 0.6 cN filaments were perceived (hypoesthesia), but the 2 cN filament was reported to be painful (allodynia).

Imaging

Standing lumbar and thoracic antero-posterior, and lumbar lateral, oblique, flexion, and extension X-rays were performed. The antero-posterior X-ray (Figure 3A) revealed a lumbarized 12th thoracic vertebra (arrowhead, confirmed as T12 with a thoracic view) and a partially sacralized L5 vertebra. The neutral lateral lumbar spine image showed a slightly reduced lordosis (Figure 3B). In extension, the left superior articulating facet of L5 was seen to jut into the L4-5 intervertebral foramen (IVF; Figures 3C and D), and there was a grade 1 retrolisthesis of L4 on L5. MRI of the lumbar spine showed mild narrowing of the left L4-5 IVF (Figure 3E, arrowhead). To determine if there was and pathology affecting the saphenous nerve, it was imaged using ultrasound (from the middle of the thigh to the middle of the shin), and was found to be unremarkable.

Diagnosis

The patient was diagnosed with chronic dynamic inflammatory stenosis of the L4-L5 IVF, discussed in detail below.

Treatment

Two initial treatments were performed as a diagnostic measure, using manual therapy maneuvers biomechanically consistent with opening the involved IVF. The patient was placed prone and the lumbar spine was mobilized in rotation and traction by counter-rotating the pelvis and lumbar spine, using one hand to grasp the anterior ilium while the other palm was placed over the transverse processes of the ipsilateral lumbar spine to stabilize. Each segment was mobilized separately bilaterally using a rhythmic rocking motion. The lumbar spine was then distracted by placing the operator's palm on the sacrum, followed by a cephalad to caudad force, which included both rhythmic oscillations and stronger high velocity but low amplitude pulses. To specifically open the left L4-L5 IVF, the patient was placed on her right side with her torso rotated to the left to the limit of comfortable range of motion, in preparation for side posture spinal manipulation. The operator's thenar eminence was placed on the ileum, and the left hand stabilized the left shoulder of the patient. The operator's right middle finger pulled on the L5 spinous process while the index finger pushed on the L4 spinous process. An impulse was delivered but did not lead to the intended intersegmental movement, which is typically associated with an audible crack or pop. Repeated nerve provocation testing showed that there had been no change. The next day the patient returned, and similar procedures were performed. On this visit however, the side posture manipulation led to a palpable and audible intersegmental movement. The femoral and sciatic nerve testing was performed immediately after this treatment but did not evoke shin symptoms. For two weeks following this treatment, all pain, both ongoing and provoked, were reported to have been absent, after which symptoms reappeared in a less severe form. The patient was referred to a chiropractor for continued care, and received three treatments within a month, similar to the initial treatment with the addition of flexion-distraction technique, also designed to open the IVFs.[6] After each visit, the patient was symptom-free, and after the third visit the symptom relief was maintained. The patient was reevaluated by the author 6 months following the first treatment. Her leg was symptom-free, and she reported one episode of back pain that lasted three days, with an unknown trigger. Sensory examination of the leg was unremarkable, with normal perception thresholds for light touch (0.04

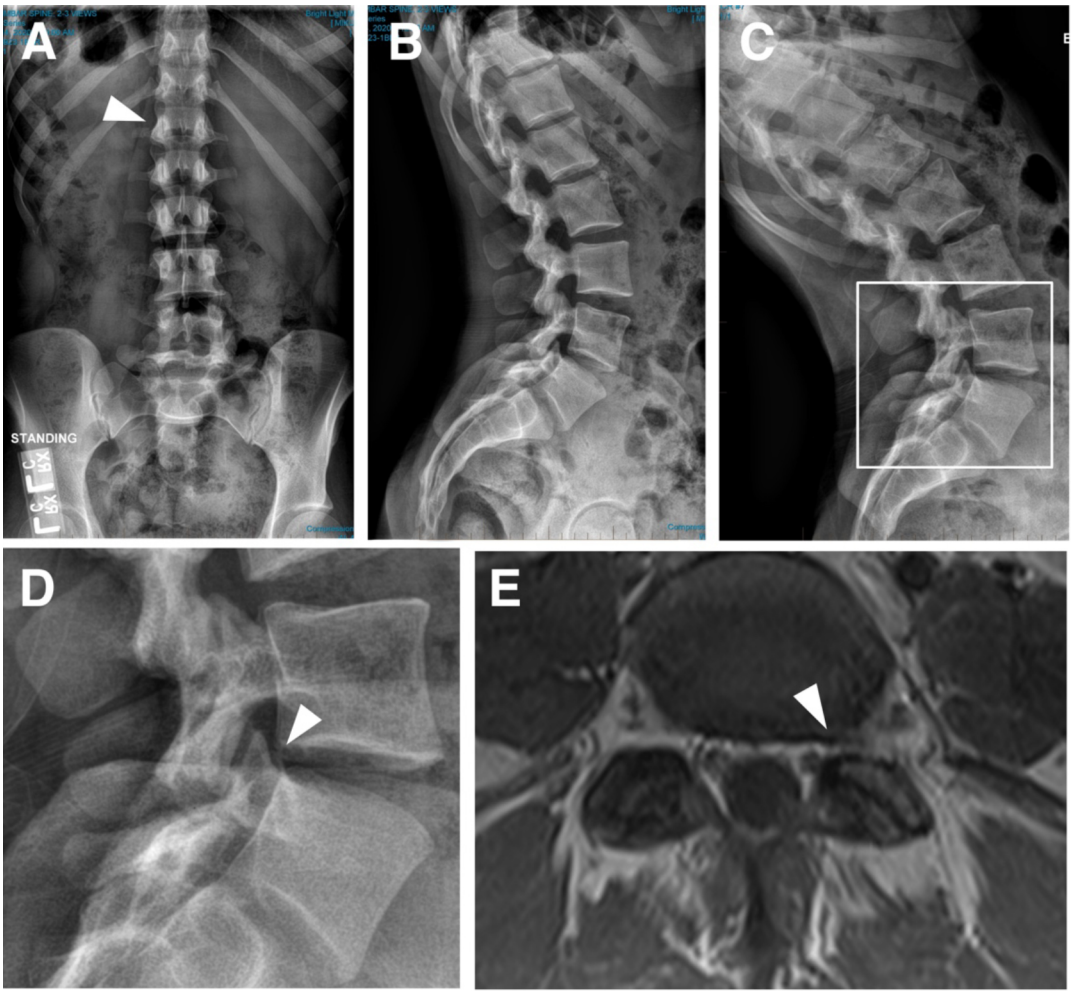

Figure 3.
Imaging of the lumbar spine. A. Anteroposterior lumbar spine, showing lumbarized T12 (arrowhead). B. Lateral lumbar spine. C-D Lumbar extension, showing dynamic stenosis of the L4 intervertebral foramen and retrolisthesis of the L4 vertebra (arrowhead). E. MRI (T1-weighted image) revealed mild static stenosis of the left L4 intervertebral foramen (arrowhead).

cN) and nociception (6 cN) bilaterally. The interspinous ligaments between L4 and S1 remained tender. Lumbar spinal movements were deemed normal. Sciatic and femoral nerve testing did not lead to any symptoms in the leg or in the lower back. At this writing the patient has remained symptom free of the presenting complaint, more than three years after the initial treatment.

Discussion

This patient presented with pain perceived to be deep in the anteromedial leg, and a combination of focal hypo- and hyperesthesias in the territory of the terminal branch of the saphenous nerve. These symptoms are consistent with a mixed sensory neuropathy of the L4 spinal nerve. This initial diagnosis was confirmed using the straight leg raise and the femoral nerve stretch, both of which reproduced the chief complaint of pain in the anteromedial shin. The straight leg raise moves the lumbosacral plexus,[7] which starts at L4. The femoral nerve test tractions the L2-L4 spinal nerves.[8] The only spinal nerve in common with these two tests is L4, thus specifically indicating its involvement. Mild static and dynamic stenosis of the left L4-L5 IVF was confirmed by dynamic plain film X-ray imaging and MRI. While it is commonly held that such mild narrowing of the IVFs is not clinically relevant, this does not consider the possible effects of dynamics of

the motion unit or of inflammation within IVFs, both of which are here posited to be relevant to the clinical presentation.

Pre-clinical observations offer mechanisms for all the painful symptoms suffered by this patient. Passive and repeated hyperextension of the lumbar spine during pole vaulting (the left leg was the launch/stance leg) likely rendered the offending facet joint hypermobile (as seen on the x-ray extension image) and allowed intermittent compression of the L4 spinal nerve. The repeated compression coupled with the excursions of the nerve during normal leg movements[7,9] likely led to inflammation of the nerve[10], known to cause nociceptor axons to fire ectopically and to become sensitive to mechanical and chemical stimulation[11-14]. The paresthesia present at the initial examination was consistent with focal pressure on the L4 spinal nerve and/or axonotmesis. Pre-clinical studies have revealed that nerve inflammation induces ectopic axonal sensitivities.[15,16] Focal nerve inflammation intended to model what may occur in the IVF, induces mechanical sensitivity of nociceptor axons.[11,15,17] This phenomenon is clinically consistent with pain during movements that press or otherwise stress on the nerve, and can occur following focal axoplasmic flow restriction without inflammation.[15,18] Similar research has shown that inflammation also induces nociceptor axons to become sensitive to inflammatory chemicals.[12,19] Clinically this is consistent with pain at rest. Ectopic nociceptor discharge has been shown to induce central sensitization, leading to cutaneous hypersensitivities as documented in this patient.[20] Chronic low levels of nerve inflammation can also lead to signs of axonotmesis consistent with this patient's hypoesthesia, and intraneural inflammation.[21-24] These phenomena have been shown to heal with the resolution of inflammation.[25]

Why this injury only seemed to affect a small part of the L4 spinal nerve is unknown. However, it is unlikely that this is an isolated presentation of a neuropathy, since the presentation of radiating pain syndromes is rarely consistent with segmental or specific nerve distribution patterns.[26] Applying the pre-clinical findings discussed above to cases presenting with radiating pain, including patients with discal herniations, should prove beneficial in the diagnosis, and thus the treatment, of these often-difficult cases.

In this case the single spinal manipulative therapy session immediately relieved the spontaneous and evoked symptoms, a phenomenon that is frequently reported in practice but is not understood. It seems highly unlikely that the presumed inflammation dissipated immediately. However, inflammation is known to cause fibrotic adhesions (scar tissue) in the intervertebral foramina,[27,28] which can tether spinal nerves. Limb movements that call for the spinal nerve to slide, such as hip flexion, would be predicted to transmit abnormal forces to a nerve caught in scar tissue. This could provide the mechanical stimulation to cause the evoked pain and potentially compress the nerve. It is feasible that the manipulation and/or mobilizations disrupted such an adhesion, removing the stimulus even though the inflammation remained. In such a scenario, it would be expected that the adhesion would reform, and that repeated treatments would be required to prevent recurrence, until the inflammation has resolved. In this single case study and with the limitations of current imaging technology it is impossible to verify the proposed mechanism. Interestingly, the immediate (and now maintained) cessation of cutaneous hypersensitivity, likely due to central sensitization, is consistent with previous reports using local anesthetic injections in select cases of neuropathic pain.[29]

Treatments that do not work are often highly diagnostic; in this case, the lack of response to treatments of the shin directed the current practitioner to look more proximally, leading to an accurate diagnosis and treatment approach. In this case, these were indicated by the consultation and physical examination. The plain film findings in extension were important to the final diagnosis. The advanced imaging (MRI and ultrasound) and specialized sensory testing were deemed necessary for this case presentation, but were not necessary for the diagnosis and treatment approach. Finally, it is unknown why the lumbar spinal manipulative treatment that was previously provided did not have a clinical effect on the symptoms, which were reported by the patient to have been severe at that time.

It is unlikely that the treatment permanently resolved or even addressed the mild stenosis or the hypermobility of the spine, leaving the long-term prognosis unknown. The inflammatory process and resulting symptoms could reoccur with resumed intense physical activity, as well as with age-related degenerative changes. The patient was apprised of this likelihood, and was taught exercises

to help stabilize the torso and lower lumbar spine, and movements that may help maintain nerve mobility.

Patient's perspective

Besides the obvious physical pain that I endured for so many years and the setbacks I experienced in my athletic career as a result, the process of seeing different doctors, trainers, and therapists to address my pain led me to immeasurable frustration. I blindly trusted the medical and sports professionals that I saw and they had let me down repeatedly. Upon discovering how straight-forward my condition was and beginning to receive the proper treatment, I experienced not only physical relief from the pain but emotional closure that the pain and complications were not just in my head but were in fact real and, more importantly, could be alleviated and repaired. I am now delighted to be injury free, and I have gotten to experience all over again what it is like to be able to run and move free of pain. I am disappointed that it took so long to get to this point and that I missed out on so many opportunities and unreached potential because of it, but I recognize that this experience has made me a stronger person. I have restored some of my faith in medical professionals but this whole experience taught me the importance of trusting my own body and what I feel instead of what others tell me I should be feeling, as well as getting multiple opinions from professionals before settling.

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Principles of Professionalism in Health Care: A Guide to Building Relationships of Trust, 2nd Edition

F. Stuart Kinsinger

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At the outset of this review, I need to make a disclosure. Dr. Kinsinger and are both graduates of the Bioethics and Health Policy master's degree (MA) program at Loyola University of Chicago. My area of interest and expertise is in research bioethics, while Stu's focus has always been on professional ethics. He and I have collaborated in the past in presenting workshops at the Association of Chiropractic Colleges Research Agenda Conference (ACCRAC) and we also worked together to organize that very conference. Professional ethics has been an area of interest that Stu has worked hard on within the chiropractic profession, and this volume is a final expansion of his thoughts and writings on this subject. As a result I will limit my comments to description of the text alone.

This is the second edition of this book. It updates and adds significantly to the first edition, and focuses very clearly on what it means to be a professional and to act professionally. It contains six chapters that cover the gamut of topics related to being a member of a profession and act ethically within it. It begins, in its first chapter, by defining what a professional is, what professionals profess, and what settings do professional operate within. One of the unique things about this book, which begins in this first chapter, is that it offers scenarios for the reader to apply the knowledge from that chapter. Each chapter has such scenarios, none of which have easy or obvious answers but all of which require deeper thought and application.

The second chapter deals with the larger world of ethics. There are really two parts to this chapter. The first section introduces basic elements of ethics, including autonomy, beneficence and non-maleficence, justice, veracity and confidentiality. That is, professionals limit harm while enhancing benefit, keep information confidential, tell the truth and provide care across the spectrum of people. In the second part, the text turns toward the professional setting, and includes information about accountability, empathy, excellence, fortitude, integrity, prudence and fidelity.

The third chapter focuses on boundaries and professional behavior. In an era of @MeToo, this is especially valuable information. This is an area that Dr. Kinsinger has discussed and presented on for many years and the depth of coverage in this section is detailed and comprehensive. It is a reminder that we should never cross those boundaries.

As the text moves on, it shifts its focus to conflict of interest, in which the potential for conflict is identified in many different areas of the professional's life, including finance, leisure time, personal and professional gratification, and more. It is all too easy to justify to ourselves the "need" to offer a supplement to a patient, yet we need to be careful and always put that patient first.

The fifth chapter examines professional responsibilities. One of the more prominent and significant sections in this chapter is information provided on how one might resolve a professional ethical dilemma. A 3-step process is identified for the reader. A latter part of the chapter looks at how a professional can demonstrate leadership- by listening, demonstrating empathy, helping the healing process, and a number of other components one might bring to bear. Leadership also relates not just to the patient, but to the community, the profession, and to regulators.

The final chapter dives into the actual challenges of being a professional- its effects on family, on burnout, potential impairment or addition, and more It offers guid-

ance to the reader on how and where one might seek help when needed. Life does occur while we are off doing other things. This is a stark but needed reminder that it is okay to seek that help.

The text runs to a concise 107 pages, but is replete with good information. It covers an area that is discussed mainly in the business courses within the profession but lays out a framework that may be beneficial for the reader. It may offer benefit to practitioners as well, as a reminder of what it means to be a professional offering help to hurting humanity.

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