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Exercise Prescription for Chronic Disease Management

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A thesis submitted in partial fulfillment of the requirements for the degree in Doctor of Philosophy

EXERCISE PRESCRIPTION CONSIDERATIONS FOR CHRONIC DISEASE MANAGEMENT

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by

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Abstract

The beneficial role of exercise in chronic disease management is well recognized, but the challenge of effective exercise prescription within primary care persists. Initiatives requesting clinicians to prescribe specific exercises to their patients has left two underlying questions: 1) Who is the most appropriate clinician to prescribe exercise to meet the unique needs of individuals living with more than one disease; 2) How does this clinician ensure appropriate and safe exercise prescriptions are provided?

Three studies were completed to begin addressing the aforementioned questions. A nationally distributed survey compared exercise curricula between physiotherapy, nursing, and medical programs, while a systematic literature review showed overlapping physiological and subjective markers that clinicians may use to define safe exercises for individuals living with multiple chronic diseases. Finally a novel approach and a preliminary tool are presented to help guide *how* exercise prescription could be implemented in primary care.

Findings suggest that PTs should lead the exercise prescription movement in primary care with nurses and physicians as exercise advisors or facilitators. Evidence from this thesis supports improving access to PT in primary care. Also, exercise prescription in individuals with multiple chronic diseases from a body-systems perspective is proposed, rather than solely relying on the dominantly available single-disease exercise guidelines. Finally, a newly developed exercise prescription approach is presented, which takes into account the advisors role in exercise prescription, while a preliminary tool is proposed that considers physiological and personal profiles of

individuals who have more than one chronic disease, to guide clinicians in developing tailored exercise prescriptions in the primary care context.

Keywords: chronic disease, exercise, curriculum, prevention & control, disease management, exercise prescription, primary care, health promotion.

Co-Authorship Statement

The written material in this thesis is the original work of the author. Nina Hovanec participated in all aspects of the work from conception of the research questions, data collection and analysis to the authorship of the manuscripts. Two of the three studies have been published, while one is in preparation. Several co-authors contributed to the publications and their role for each chapter is detailed below.

Chapter 2:

The concept of this study was shared between N. Hovanec and Dr. Anthony A. Vandervoort. N. Hovanec completed questionnaire development, distribution, coordination of data collection, qualitative and quantitative data analysis, and composition of the manuscript. Dr. Vandervoort, Dr. Tom Overend, and Dr. Robert Petrella reviewed and assisted in the completion of the questionnaire. Dr. Vandervoort and Dr. Overend provided valuable input to the manuscript entitled <u>Formal exercise curricula in Canadian physiotherapy, nursing, and medical schools</u>, published in *Jacob's Journal of Physiotherapy & Exercise* (2015), 1(1), 1-9.

Chapter 3:

The concept of this study was shared between N. Hovanec and Dr. Vandervoort. N Hovanec developed the research question, guided the search strategy, created a data extraction template, and provided iterative feedback from study inception to completion. Dr. Vandervoort provided valuable input to the manuscript, while D. Bellemore, J. Kuhnow, F. Miller, and A. van Vloten completed the following tasks: database literature searches, data extraction, and wrote the initial draft of the article entitled <u>Exercise prescription considerations for individuals with multiple chronic disease: systematic review</u>, published in *Gerontology & Geriatric Research* (2015), 4(1), 1-10.

Chapter 4:

The concept of this study was shared between N. Hovanec and Dr. Vandervoort. The conceptual exercise prescription approach was informed by relevant literature and developed by N. Hovanec under the guidance of Dr. Vandervoort. Dr. Overend and Dr. Vandervoort were instrumental in providing valuable input during the development of the manuscript currently in preparation to be published within the *American Journal of Preventative Medicine.*

This work is dedicated to the other three musketeers:
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List of Key Terms

Chronic Diseases	Conditions that develop over time and may be controlled, but not cured.
Chronic Obstructive Pulmonary Disease	Chronic bronchitis & emphysema: lungs are obstructed or blocked, making it difficult to breath.
Chronic bronchitis	Airways become swollen and can be filled with mucus, making it difficult to breath.
Coronary Artery Disease	Heart disease where arteries in the heart are blocked. May lead to complications such as angina (chest pain), or heart attack if the heart doesn't get enough oxygen
Type 2 Diabetes Mellitus	Disease where the body resists effects of insulin (hormone that regulates the movement of sugar into cells); or when not enough insulin is produced to maintain a normal glucose (sugar) levels in the blood.
Emphysema	Air sacs (alveoli) in your lungs are damaged, making it difficult to breath.
Exercise	Formal and structured form of physical activity i.e., includes specifics such as frequency, intensity, time, and type. (examples of exercise: lifting 10 pounds for 3 sets of 10 repetitions 3 times per week; running for 60 minutes 7 days per week at an intensity permitting one to speak in brief sentences/few words)
Metabolic Equivalent of Task	Physiological measure expressing energy cost of physical activities; rate of energy consumption.
Older Adults/Seniors	Individuals who are at least 65 years old.
Physical Activity	Unstructured use of muscles, involving expenditure of energy. (examples of physical activity: walking to a grocery store, gardening, raking leaves…)
Physiological Marker	Objectively measured, have a physiological effect on the body (examples of physiological markers: heart rate, respiratory rate, blood pressure)
Primary Care	Health care services, including health promotion, illness and injury prevention, the diagnosis and treatment of illness and injury.
Subjective Marker	Self-report measures such as Rate of Perceived Exertion (i.e., how difficult the person perceives their level of activity to be on a scale from 0-10 or 6-20, the higher the number the greater the intensity)

List of Abbreviations

Bpm	Beats per minute
CAD	Coronary Artery Disease
COPD	Chronic Obstructive Pulmonary Disease
DBP	Diastolic Blood Pressure
EMR	Electronic Medical Record
HR	Heart Rate
MD	Medicine and/or Medical Doctor
O_2	Oxygen
PT	Physiotherapy and/or Physiotherapist
RCT	Randomized Control Trial
RN	Nursing and/or Registered Nurse
RPE	Rate of Perceived Exertion
RR	Respiratory Rate
RT	Resistance Training
SBP	Systolic Blood Pressure
SpO_2	Peripheral capillary oxygen saturation
T1DM	Type 1 Diabetes Mellitus
T2DM	Type 2 Diabetes Mellitus
VO_2	Volume of oxygen consumed

Chapter 1: General Introduction

It is estimated that 56% of two million Ontarians who are currently over the age of 65 have at least two chronic diseases[1-3] with direct and indirect healthcare costs surpassing $90 billion.[2] Although chronic diseases are among the most common and costly health problems in Canada, their complications may be prevented and controlled through appropriate healthcare strategies.

The beneficial role of exercise for prevention and management of chronic diseases is well recognized in numerous exercise guidelines published by industry and academic leaders.[3-5] All currently available exercise guidelines are geared towards the general population in a specific age bracket, or to those living with a single disease. However, in reality over 50% of older adults are affected by more than a single chronic disease,[6] making it challenging to translate the currently available evidence on an individual level. The need to tailor exercise recommendations on an individual basis has been identified as necessary when working with clinical populations.[5,7,8] Despite this acknowledgement, an effective strategy to accomplish such a task is yet to be established.

Although initiatives such as Exercise Is Medicine (EIM) by the American College of Sports Medicine[9] have emerged, requesting clinicians to prescribe specific exercises to their patients has left two underlying questions: 1) Who is the most appropriate clinician to prescribe exercise to meet the unique needs of an individual living with more than one chronic disease; 2) How does this clinician ensure appropriate and safe exercise prescriptions are provided?

It has been previously suggested that physicians[10-12] and nurses[13] are potential candidates to provide individually tailored exercise prescriptions. However, time demands along with lack of confidence and formal exercise science knowledge have repeatedly emerged in the literature as barriers for physicians to effectively and confidently prescribe exercise within their regular practice.[13] This may not be surprising given that approximately 87% of US medical schools do not include instructions on the health benefits of exercise, nor do they offer any kind of exercise curriculum. Furthermore, 76% of these schools have no plans to include such a curriculum in the future.[14] Similarly, researchers from the UK obtained a 100% response from all medical programs in England and found that exercise was limited or completely absent from the medical schools' curricula.[15]

A recent systematic review recognized the potential limitations of solely relying on physicians to prescribe specific exercises to clients.[13] These authors suggested nurses as being the most appropriate healthcare provider to incorporate exercise counseling to clients as a component of their health promotion role.[13] However, high burnout rates and absenteeism have been reported with seasoned, as well as recent nursing graduates, in part attributed to the increasing job demands and complexities of their role.[16] Furthermore, the nursing profession does not typically offer extensive (or any) training in exercise science.[17] Placing another obligation, such as exercise prescription, onto already overtaxed healthcare providers stands the risk of further exacerbating previously identified barriers and limitations (e.g., time-demands and expertise gap).

Recognizing the limitations of the aforementioned primary care providers' role in exercise prescription, the hypothesis presented in this thesis is that the ideal primary care provider that may effectively prescribe and monitor exercise are physical therapists, who need to be considered as core team members for all chronic disease management interventions. The reasoning behind this hypothesis is evidence-informed and grounded in the unique and relevant role of physiotherapists, as defined by the Canadian Physiotherapy Association:[18]

"Physiotherapy is a ***primary care****, autonomous, client-focused health profession dedicated to improving quality of life by:* ***Promoting optimal mobility, physical activity and overall health and wellness*** *[through];*

- *Education, consultation, health promotion and prevention services.*
- ***Personalized therapeutic exercise*** *including testing and conditioning, neurotherapeutic approaches to improve strength, range of motion, and function.*
- *Preventing disease, injury, and disability;*
- ***Managing acute and chronic conditions****, activity limitations, and participation restrictions;*
- *Improving and* ***maintaining optimal functional independence*** *and physical performance;*
- ***Rehabilitating injury and the effects of disease or disability with therapeutic exercise programs*** *and other interventions; and*
- ***Educating and planning maintenance*** *and support programs to prevent re-occurrence, re-injury or functional decline."*

Based on the description of physical therapy practice and given the previous evidence on positive impact of physiotherapy interventions in individuals with chronic disease(s),[19,20] physiotherapists may be best prepared to address the challenges associated with exercise prescription within the primary care context for the purpose of chronic disease prevention and management. Primary care context refers to services that the public can directly access, such as prevention and treatment of common diseases, health promotion, palliative care, and rehabilitation. In Canada, family physicians, nurses and general medical practitioners, along with physical therapists are examples of professionals who deliver primary care services.[21]

The context of primary care is changing with a shift towards a team-based approach to healthcare delivery. There is now consensus that having such an approach will increase access to services and also improve health promotion as well as chronic disease management.[21] When identifying who should comprise core members of such teams, consideration ought to be given to a provider that is best prepared to effectively prescribe exercise to address the complex needs of individuals with/or at risk of chronic disease(s). However, at this time evidence is required to illustrate the primary care provider who is best prepared to lead exercise prescription within the primary care context for the purpose of chronic disease prevention and management. This initiative fits well with the mandate of Health Canada's health care reform, which begins addressing the long-called improvements in health promotion, disease prevention, and chronic disease management within the primary care context.[22,23]

A mixed-methods design was employed to begin addressing the aforementioned limitations and knowledge gaps. Brief descriptions are provided below, but each study is further elaborated in subsequent chapters of this thesis.

Study 1: The "Who" of Exercise Prescription

Study 1 is presented in chapter 2 of this thesis. This study is divided into two phases. Phase one includes the distribution of a survey to directors of physiotherapy, medical, and nursing programs across Canada. Descriptive statistics with chi square analysis of key findings were used to demonstrate the amount of time and resources devoted to teaching respective professional programs' students about exercise. Furthermore, thematic coding was completed for the questions that provided text-boxes for participants to share further comments.

In phase two, a detailed document analysis was completed to determine the exercise education backgrounds of physiotherapy students in Ontario attained prior to commencing a Masters' program in physical therapy. Specifically, the Ontario

Rehabilitation Sciences Programs Application Service (ORPAS) data between 2008-2012 were reviewed to determine the specific undergraduate education of students accepted into one of the four Ontario-based Masters' program in physiotherapy. For the purpose of this study, data (i.e., pre-Masters' education in physiotherapy) reviewed focused mainly on Ontario-based PT programs rather than Canada. This was done for two main reasons: 1) limited funding; 2) Ontario has the highest concentration of physiotherapy programs, which are attended by students from across Canada providing a representative sample of the type of educational background attained by students who choose to pursue post-graduate education in physiotherapy.

Study 2: The "What" of Exercise Prescription

The second study includes a systematic review that is presented in chapter 3 of this thesis. The systematic review was completed between September 2013 until August 2014 and it presents the evidence on exercise prescription for three major chronic diseases from three different systems of the body: type 2 diabetes mellitus (endocrine system), coronary artery disease (cardiovascular system), and chronic obstructive pulmonary disease (respiratory system). The purpose of this review was to extrapolate key markers that ought to be monitored for safe exercise prescription in populations with more than a single chronic disease. It introduces a novel perspective on exercise prescription considerations from a physiological systems perspective, rather than the currently dominant one, which focuses on exercise guidelines taking into account a single chronic disease.

Study 3: The “How” of Exercise Prescription

The third study, detailed in chapter 4 of this thesis introduces an innovative exercise prescription approach to begin addressing the underlying question of *how* to tailor appropriate exercises when working with individuals living with multiple chronic diseases, rather than solely relying on guidelines that are often too broad or relevant for the needs of a person living with a single disease. The proposed exercise prescription approach first discusses how exercise prescription may be incorporated within primary care, and then conceptual algorithms are provided to discuss how a future electronically based tool could assist in the production of a personalized exercise prescription. A person’s physiological and personal profile, coupled with clinical reasoning and client collaboration are all key components included in the proposed tool to help inform the exercise prescription decision-making process.

Details of each study are summarized in subsequent chapters, presented in individual manuscript formats, while the discussion chapter shares final insights gained from completing this research, including some of the limitations encountered throughout the process, as well as potential future research directions.

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Chapter 2: Formal Exercise Curricula in Canadian Physiotherapy, Nursing, and Medical Schools

Introduction

Addressing risk factors of chronic disease means that approximately 80% of leading chronic diseases, such as premature heart disease, stroke, and diabetes could be prevented.[1] Although this is well known and exercise is also recognized as a key cornerstone in chronic disease management, effective implementation of exercise within primary care continues to be a challenge. According to Health Canada,[2] primary care is the element within primary health care that focuses on health care services, including health promotion, illness and injury prevention, and the diagnosis and treatment of illness and injury. While primary health care refers to an approach to health and a spectrum of services, including all services that play a part in health, such as income, housing, education, and environment. Thus, for the purpose of this paper, primary care is the operational definition used to describe the practice context relevant for physicians, nurses, and physiotherapists.

Several recent initiatives, such as exercise guidelines for specific groups, a developing role for kinesiologists and clinical exercise physiologists (still to be fully determined), and the "exercise is medicine" movement have attempted to bridge the gap between knowing exercise is beneficial and incorporating it within primary care.[3-5] In instances with more complex healthcare needs, exercise guideline readers will often be referred to speak with their healthcare provider for additional guidance and support regarding safe and appropriate exercise recommendations within a clinically monitored setting. However there are two assumptions that ought to be recognized within such a referral: 1) the reader will know which primary care provider to turn to for additional exercise recommendations for their unique health needs, and 2) the healthcare professional is prepared to provide appropriate, safe, and effective exercise recommendations.

From the relevant literature, we found that several authors[6-10] made compelling advocacy for including physicians to play a key role in exercise counseling and prescription, while others[11] suggest nurses incorporate exercise recommendations as part of their health promotion role. However, in practice few physicians consider exercise during their examinations,[12] which is not surprising given that medical schools in the United Kingdom and United States have limited (if any) exercise education within their curriculum[13,14] and minimal opportunity to design a specific exercise prescription.[12] Notably, this type of research has not yet been reported for Canadian medical or nursing schools. Thus, given the acknowledged benefits of exercise, along with the initiatives to incorporate exercise prescription within the primary care context, evidence is needed to determine which healthcare provider is formally trained and thus best prepared to implement effective exercise prescription within our present healthcare system.

A two-phase study was conducted to compare physiotherapy (PT), nursing (RN) and medical (MD) program curricula to determine whose students may be best prepared to prescribe exercise within primary care for the purpose of chronic disease prevention and management. In phase 1 a survey was distributed to compare the formal exercise curriculum offered in Canadian PT, RN, and MD programs. Phase 2 included an in-depth document review of PT programs listed in the Ontario Rehabilitation Sciences Program Application Service (ORPAS) from 2008-2012, in order to determine the typical educational background of students coming into physiotherapy programs.

Methods

We developed a survey for phase 1 based on previous literature[13] and feedback from several researchers with questionnaire experience to cover the basic aspects of exercise knowledge gained during the duration of the professional program. The study has been approved by the appropriate ethics review board(s) (Appendix A), informed consent has been obtained for all participants and the study conforms to the Human and Animal Rights requirements of the February 2006 International Committee of Medical Journal Editors' Uniform Requirements for Manuscripts Submitted to Biomedical Journals.

An electronic version of the survey was prepared for distribution to potential study participants following ethics approval. A telephone call was made to 15 PT, 17 MD, and 24 RN schools across Canada, to introduce the study and confirm the most appropriate person who could comment on curriculum details for their respective program. Director is the term used throughout the paper to define this person, even though the official titles varied (e.g., Deans, Program Chairs, Leads, Directors, etc.,). From the initial contact made with the administrator, the appropriate person was secured for 10 PT, 12 MD, and 17 RN programs. Each of these program directors was e-mailed a copy of the study's cover letter, consent, and the electronic uniform resource locator (URL) directing participants to the online survey, which took a maximum of 10 minutes to complete. The URL enabled automatic data collection within the appropriate, electronic, password-protected folders labeled PT, RN, or MD, which helped minimize human error during data tabulation and analysis. One week after the initial contact, a follow-up e-mail was sent to all identified directors, which was subsequently followed by a reminder telephone call one week later. Participants were given eight weeks to complete the survey, with a reminder e-mail sent once per week.

The questionnaire helped quantify participants' responses based on specific questions from eight categories (Table 1), including: 1) beliefs about exercise prescription; 2) the "how" of exercise prescription; 3) safety and exercise prescription; 4) exercise advice, benefits, and physiological effects; 5) current exercise prescription curriculum; 6) future curriculum plans; 7) exercise prescription and chronic disease; and 8) utilization of specific exercise guidelines. Open-ended free form text boxes were provided for further commentary that participants felt was important to share.

Table 1: Questionnaire categories and respective survey questions used to inform each category

Category	**Question (#, Content)**
Beliefs about exercise prescription	1) We believe that giving advice to be physically active is the same as providing a specific exercise prescription. 2) We believe that teaching students how to prescribe exercises to clinical populations should be mandatory.
The how of exercise prescription	3) We teach students how to design an exercise program for individuals living with medical conditions. 4) We teach our students to prescribe exercise(s) using specific criteria (e.g., frequency, intensity, sets, repetitions, duration, etc.,). 5) We teach our students how to implement an exercise program.
Safety and exercise prescription	6) We teach our students established exercise precautions. 7) We teach our students established exercise contraindications. 8) We teach our students what to monitor to ensure safety during exercise.
Exercise advice, benefits, and physiological effects	10) Our students are taught how to advise patients about the benefits of exercise. 11) We have dedicated lectures to teach our students the physiological effects of exercise on chronic disease(s).
Current exercise prescription curriculum	13) We have at least one course dedicated to teaching students about the benefits of physical activity/exercise. 14) Exercise prescription is intergraded within mandatory courses. 15) Our curriculum provides a sufficient amount of exercise/physical activity instruction.
Future curriculum plans	16) In the next 5 years we plan to have a course dedicated to teaching our students how to prescribe exercise/physical activity to clinical populations [i.e., individuals living with chronic condition(s)].
Exercise prescription and chronic disease*	12) We teach our students how to prescribe exercise to populations living with the following (check all that apply): Type I diabetes; Type II Diabetes; Coronary Artery Disease; Stroke; Multi-System Involvement; Other
Utilization of specific exercise	9) In order to teach our students specific physical activity recommendations, we use exercise guidelines from the following (check all that apply): we do not use

guidelines*	any established guidelines; American College of Sports Medicine, Canadian Physical Activity Guidelines, Canadian Society for Exercise Physiology, Other.

Note: *Questions provided text boxes for participants to share additional information under “other”.

Chi Square analysis with Fisher’s Exact Test was done to assess the main difference in responses between PT, RN, and MD program directors. Frequency analysis was completed and t-tests were done to compare PT and RN directors’ answers. Data attained from responses given by MD directors were excluded from the t-test analysis due to the low response rate (4/12, 33%). However, word responses were reviewed and their content thematically analyzed[15] to illustrate perspectives shared by directors from all three professional programs.

In phase 2, the Ontario Rehabilitation Programs Application Services (ORPAS) was e-mailed and the request for permission to review and present the data included in their annual report was granted without ethics approval. Information from 2008-2012 was reviewed to assess the formal exercise academic background (i.e., undergraduate degree), of students who chose to attend one of four Ontario-based, professional masters programs in physiotherapy. Similar information about the academic background of students admitted to medical schools was not made available by the Ontario Universities’ Application Center (OUAC), as their representative expressed that they do not release these details to anyone who does not have “an ongoing relationship with OUAC”. Data on pre-nursing education was also not obtainable, given the heterogeneity of nursing programs across Ontario (i.e., Community/College-based, University-based, or combined and graduate programs at universities).

Results

Results are presented in two main sections, including Phase 1: Survey Findings and Phase 2: the ORPAS document review.

Phase 1: survey findings. Response rate and chi square analysis are described first. The rest of the survey findings are presented under the previously introduced questionnaire categories (Table 1). Although the questionnaire was e-mailed across Canada, program directors from different provinces were reached for each professional program with varying response rates (Table 2).

Table 2: Study participants' programs, provinces, and response rates.

Professional Program	Program Directors' Respective Provinces	Response Rate*
Physiotherapy	Alberta; British Columbia; Manitoba; Quebec; Ontario	n=10, 100%
Nursing	Alberta; British Columbia; Ontario; Saskatchewan	n=10, 59%
Medicine	Alberta; Ontario; Quebec	n=4, 33%

*Note: Response rate is based on the responses obtained from program directors whose contact details were secured, not the total number of programs in all of Canada.

Main response difference. Based on the chi square analysis using Fisher's Exact Test, a statistically significant ($p<0.001$) difference was noted in the way the questionnaire was answered by PT, RN, and MD directors.

The t-test analysis comparing PT and RN responses for the following 13 Likert-scale survey questions, were statistically significant (range: $p<0.001$to $p=0.008$). A table with response frequencies can be found in Appendix B, while the t-test analysis table is shown in Appendix C. Despite the low response rate and exclusion of MD director responses from the t-test analysis, their contributions are included to illustrate key trends. Study participants' comments are briefly presented in the findings and further elaborated in the discussion section of this paper.

Beliefs about exercise prescription. Question 1 and 2 from the survey (Table 1) assessed participants' beliefs about exercise prescription. A majority (90%) of the directors for the PT and RN professional programs disagree or strongly disagree that advice to be physically active is the same as a specific exercise prescription. The trend from MD directors' responses was similar to those of PT and RN, with only 1 of 4 (25%) reporting that these two concepts are the same. Furthermore, all PT directors believe that teaching students how to prescribe exercise to clinical populations (defined in the survey as individuals living with chronic conditions) be mandatory. The varied RN opinions substantially differ from PT responses as shown in Figure 1.

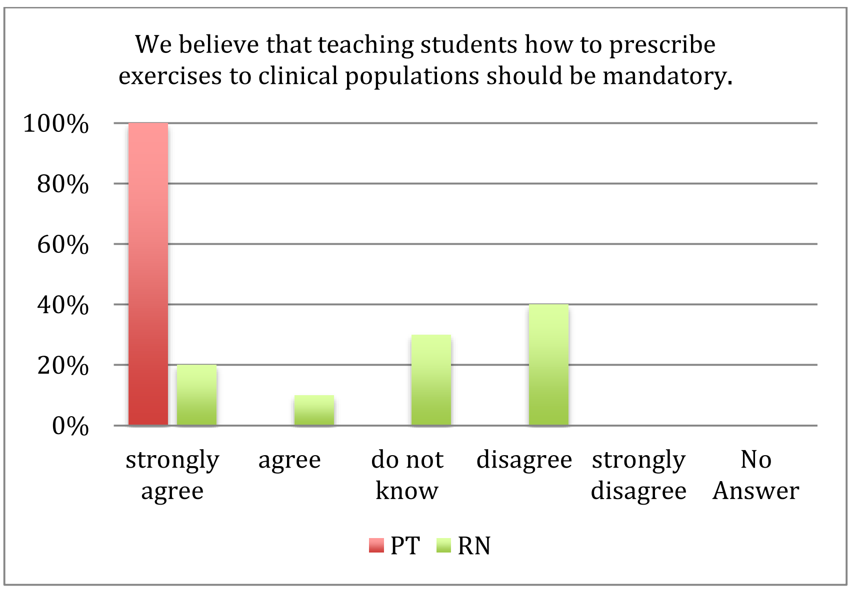

Figure 1: Program directors' belief that teaching students how to prescribe exercise to clinical populations should be mandatory. PT: physiotherapy; RN: nursing.

The how of exercise prescription. Questions 3, 4, and 5 (Table 1) comprise the *how* of exercise prescription section of the survey. All PT directors strongly agree, while the majority (90%) of RN directors disagree or strongly disagree that their students are taught how to design an exercise program for individuals living with medical conditions.

Also, all PT directors strongly agree, while the majority (90%) of RN directors disagree or strongly disagree that as part of their curriculum students are taught how to prescribe exercise(s) using specific criteria such as frequency, intensity, repetitions, etc. In addition, all PT and only 10% of RN directors agree or strongly agree that as part of their curriculum students are taught how to implement an exercise program.

Similar to RN, MD directors' responses show similar trends where they predominantly disagree or strongly disagree (90%) that their students are taught how to design an exercise program for individuals living with medical conditions, and all felt that their students would not know how to implement an exercise program or how to prescribe appropriate exercise(s) by using specific criteria.

Safety and exercise prescription. Questions 6, 7, and 8 respectively, informed the safety and exercise prescription category of the survey (Table 1). All PT directors strongly agree that students are taught established exercise precautions and contraindications, while 50% of RN directors agree and 50% disagree with this statement. In addition to teaching students about established exercise precautions and contraindications, 100% of PT directors strongly agree, while 60% of RN directors agree or strongly agree that their students are taught what to monitor to ensure safety during exercise. For MDs, response trends suggest that medical students are not taught about exercise precautions, but some suggest teaching students about exercise contraindications. There is also a divide on whether exercise prescription should be mandatory in medical schools' curriculum (see frequency details in Appendix B).

Exercise advice, benefits, and physiological effects. Survey questions 10, and 11 informed the exercise advice, benefits, and physiological effects category. Most PT directors (90%) strongly agree and 80% of RN directors agree or strongly agree that their students are taught how to advise patients about the benefits of exercise. Ten percent of PT directors did not answer this question, while 10% of RN directors disagree that their students are taught how to provide advice on the benefits of exercise. Furthermore, a majority (60%) of RN directors agree and 90% of PT directors strongly agree that they offer lectures dedicated to the physiological effects of exercise on chronic disease. Trends from MD responses are similar to those of PT and RN (see frequency details in Appendix B).

Current exercise prescription curriculum. Questions 13, 14, and 15 informed the current exercise prescription curriculum category in the questionnaire. Majority (90%) of PT directors agree or strongly agree that there is at least one course dedicated to teaching students about the benefits of exercise, while 80% of RN directors disagree or strongly disagree that they offer such a course(s). Another 70% of PT directors agree and 60% of RN directors disagree that exercise prescription is integrated within mandatory courses. Responses from MD directors show similar trends to PT (Appendix B).

When asked whether the curriculum provides a sufficient amount of exercise instruction, 60% of PT directors strongly agree that they did, while another 40% of them did not provide an answer. Forty percent of RN directors disagree, while another 40% do not know, and only 20% agree or strongly agree that their students receive sufficient amount of exercise instruction. The MD directors were divided here: 50% disagree or strongly disagree that they have sufficient instruction regarding exercise (Appendix B).

Future curriculum plans. When asked if there is a plan to provide a course on exercise prescription in five years (Question 16-Table 1), 80% of PT participants report already having such a course, while 10% will, and 10% do not have plans to include a course on exercise prescription. Some of the comments indicate that exercise prescription is an integral component of all courses, or that it is integrated throughout the curriculum rather than presented in a single course: 1) *"topics are integrated across multiple courses and both years of training, so our program is not conducive to a specific course";* 2) *"all our courses have exercise prescription as an integral component";* 3) *"we have this course, but are planning to increase it to 2 courses".*

On the other hand, 30% of RN directors plan to have an exercise prescription course, while 30% do not know and another 30% have no plans of including such a course within their curriculum over the next five years. None report already having such a course, although one comment reflects that exercise is integrated within the curriculum as a healthy living component within the broader context of health promotion, as shown by the following quote: *"We are reviewing our curriculum and plan to enhance our healthy living components, including self-care for our students as future health care professionals. We advocate a collaborative rather than prescriptive approach to healthy living, for self and working with clients, that considers the complexity of social determinants of health and focuses on empowering, respectful health promotion practice. These components are and will be integrated throughout the curriculum, rather than presented in a single course".*

An MD director commented that exercise is integrated throughout the curriculum, but recognized that there is limited coverage of this topic, which they plan to address by including *"more emphasis on the practical application of knowledge, including exercise prescription".* Another MD director acknowledged the benefit of exercise, but expressed that medical students should not be experts in the field, as evident from the following quote: *"The basic rationale for not including much specific exercise prescription instruction in the curriculum is that an MD, although cognizant of the beneficial effects of exercise, and aware of when exercise would be beneficial or not; cannot expect to also become a kinesiologist/exercise scientist/physiotherapist while they are becoming an MD. At some point, their knowledge of complementary therapies has to reach a limit so as not to compromise the completeness of their basic medical education within the 4 years of the program. Agreed on the importance of exercise, but not that med students should be the experts in this field."*

Exercise prescription and chronic disease(s). Question 12 was posed to determine what chronic disease(s) are discussed in relation to exercise prescription. Ninety percent of PT directors report teaching students how to prescribe exercises to individuals living with: chronic obstructive pulmonary disease (COPD), type 2 diabetes mellitus (T2DM), stroke (CVA), coronary artery disease (CAD), while 80% address type 1 diabetes mellitus (T1DM). Participants (30%) also provided "other" conditions including hypertension, multi-system impairments and/or individuals with comorbidities, while one PT director emphasized that there are "*too many [chronic diseases] to list*". Some of the additional conditions that emerged in the PT curriculum included: obesity, cancer, renal disease, fibromyalgia, polio, post-polio, cerebral palsy, osteoarthritis, rheumatoid arthritis, muscular dystrophy and head injury. One quote summarized that the PT curriculum included education about "*all major chronic conditions*".

In comparison, 40% of RN directors report teaching students about exercise and individuals with "*multi-system impairment*", while 30% cover CAD, T2DM, COPD, and

20% discuss CVA and T1DM. Additionally one participant explained: *"We work within a broader focus on healthy living and emphasize collaborating with clients, rather than prescribing to them. Chronic disease management, including lifestyle strategies, are included in the curriculum."*

Finally, one of the MD directors suggested that students are taught about exercises and a *"wide variety of MSK disorders"* while another one stated that their curriculum covered *"individuals living with chronic conditions."*

Utilization of specific exercise guidelines. Question 9 was posed in the survey to determine whether established exercise guidelines are utilized when educating students on exercise recommendations (Table 1). A majority (90%) of PT directors report using the following: American College of Sports Medicine (ACSM) and Canadian Physical Activity Guidelines (CPAG), while another 80% indicate using Canadian Society for Exercise Physiology (CSEP). Additionally, 30% of PT directors report using Canadian Diabetes Association guidelines and another 30% report relying on "*current evidence-based literature*". "Other" guidelines that were highlighted by PT directors include: 1) *"Position statements [from] specific professional groups such as "ATS statement for pulmonary rehab, Canadian Diabetes Association for diabetes management";* 2) *"YMCA protocol, stroke specific guidelines (i.e., Canadian Stroke Best Practice Guidelines)"* 3)*"… Canadian Association of Cardiovascular Prevention and Rehabilitation, Osteoporosis Canada (BoneFit)"*

Several (40%) RN directors report not using any established guidelines, while 30% utilize CPAG. Additionally, 10% report using ACSM and CSEP, while another 10% indicate not knowing whether any guidelines are used to teach exercise specific recommendations to nursing students. Finally, three MD directors report using CPAG, two use both ACSM and CSEP, while one reports not using any established guidelines

Phase 2: ORPAS document review. A document review of ORPAS information on undergraduate programs focusing on exercise education was completed for the year 2008-2012 (Table 3). A majority (56 to 62%) of the students accepted into one of four Ontario PT programs surveyed had an exercise-based undergraduate education (i.e., human kinetics/kinesiology, exercise science, physical & health education, and physio/physical therapy).

Table 3: Percentage of students with exercise-focused undergraduate degrees accepted into one of the potential four Ontario-based physiotherapy programs.

Undergraduate Education	**2008**	**2009**	**2010**	**2011**	**2012**
Human Kinetics/Kinesiology	55.4%	53.7%	49.5%	53%	52.1%
Exercise Science	0.7%	1.5%	1.5%	1.4%	1.4%
Physical & Health Education	3.2%	5.2%	5.1%	1.8%	2.8%
Physio/Physical Therapy	0%	1.5%	0.4%	0.7%	0.7%
Other Non-Exercise Based Education	40.7%	38.2%	43.6%	43.1%	42.9%
Total Exercise-Based Education	59.4%	61.9%	56.4%	56.9%	57.1%

Discussion

This study set out to compare physiotherapy (PT), nursing (RN) and medical (MD) program curricula to determine whose students may be best prepared to prescribe exercise within primary care for the purpose of chronic disease prevention and management. There was a notable difference in response rate (Table 2) between PTs (n=10; 100%), RNs (n=10; 59%), and MDs (n=4; 33%). This difference in response rate might reflect poor timing of the survey (i.e., distributed during the summer term). In addition, the survey might have had greater buy-in from RNs and MDs if a professional from their area of practice administered it, rather than a graduate student pursuing a combined PT/PhD degree. Furthermore, the response rate may also indicate competing research priorities amongst RN and MD program directors, which could have limited their participation. Finally, the response rate from RNs and MDs may indicate a generally lower level of interest in research regarding exercise prescription for chronic disease prevention and management. Despite the varied response rate, informative findings emerged that are further elaborated in this discussion section.

We determined that the three participating groups had an overall statistically significant difference in the way that they responded to the survey questions. Thus, we found an overall trend that exposure to exercise prescription within their curricula varied. The first section of the survey assessed beliefs about exercise prescription. Findings show that PT and RN program directors believe exercise prescription and general advice for people to be active is not the same thing, with similar trends noted from the limited number of MD responses. Recognizing the distinction between exercise advice and exercise prescription is imperative, since primary care providers should be able to provide general advice by discussing the health benefits associated with exercise and also encourage someone to be/become physically active. However, once a person is prepared to increase exercise levels, they may require additional expertise in order to commence a safe exercise program. Thus, advice initially offered by a healthcare professional for someone to increase his or her activity levels becomes insufficient, because at that point knowledge on *how* to prescribe an exercise program becomes crucial.

In order to guide a person on *how* to exercise, a question was posed whether teaching students how to prescribe exercises should be mandatory. While the findings (Figure 1) show that all PT directors strongly believe that such instruction should be mandatory, the majority of RN's did not know or disagreed with this statement. This difference might be partially explained in how RN's perceive exercise as a lifestyle component within the broader context of health promotion, as supported by one of the RN participants who stated that: "*we work within a broader focus on healthy living and emphasize collaborating with clients, rather than prescribing to them. Chronic disease management, including lifestyle strategies, are included in the curriculum*".

This comment raises an interesting perspective that this RN director may have on exercise prescription, where the word prescription is perceived as something that's done *to* the client, rather than created *with* the client at the center of the process. From this RN director's perspective, prescription might be viewed as a hierarchical or top-down approach to interacting with clients, rather than a collaborative endeavor. This perspective may be closely linked to the perception of how medication is prescribed. Medical doctors have the knowledge and training to advise clients on appropriate pharmacological interventions. Although this process could be viewed as a one-way interaction, where the physician prescribes medication(s) *to* the patient, ideally, sufficient education about the risks, benefits, and alternatives is discussed with the client and/or their substitute decision maker. Also, during this interaction the client's concerns and questions should be addressed—the essence of client-centered care.[16] As a result, the ultimate decision to take the medication is left to the now well-informed client or substitute decision maker.

Individuals seeking advice from physicians trust that the advice and in turn the medication prescription is correct, as it is provided by a professional with appropriate and extensive training in that area of practice. An exercise prescription ought to be considered in a similar way, where the individual who would benefit from this intervention would receive advice and a specific prescription from the most appropriately trained and qualified healthcare provider. That being said, an exercise prescription ought to be recognized as an iterative process where the individual who would benefit from the prescription is fully integrated and plays a central role throughout the process.

The *how* of exercise prescription. Three questions from the survey aimed to determine the *how* of exercise prescription. Questions from this section asked whether students are taught how to: 1) design an exercise program; 2) prescribe exercise using specific criteria such as frequency, intensity, duration, etc.; and 3) implement an exercise program. While all PT directors reported that their students receive this training, the majority of RN directors suggest this content is not included within the nursing curriculum, with MD directors showing similar trends to RN directors' responses.

These findings suggest that although RN and PT directors recognize that advice and giving a specific exercise prescription is not the same, only PT students are taught how to prescribe an exercise program. Also, despite medical schools being encouraged to incorporate exercise into their curriculum[9,13,14] the four MD directors from three different Canadian provinces suggest that their students are not provided with specific education on how to develop, prescribe, or implement a specific exercise program.

Exercise curriculum content. Based on the findings summarized within the following categories: 1) safety and exercise prescription; 2) exercise advice, benefits and physiological effects; 3) and current exercise curriculum, it is evident that all three primary care providers are able to discuss the physiological effects of exercise on various chronic disease(s) and advise individuals on the benefits of exercise, but the PT curricula is the only one that incorporates exercise within mandatory courses. This indicates that physicians, nurses, and physiotherapists could all play an important role as advisors to facilitate exercise participation by educating clients about the benefits of exercise. However, once a person is prepared to start exercising, PTs would be the only clinicians formally trained to design, implement, and modify an exercise program to ensure it is appropriate and safe.

Study findings also suggest that current PT programs are the only ones that provide sufficient and extensive exercise content to their students as part of their mandatory curricula. On the other hand, based on RN directors' feedback, it is evident that curricula changes would be required for their students to receive sufficient exercise instruction. Previous researchers have also called for change within medical programs to ensure future physicians are better informed on how to prescribe exercise to their clients.[13,14,17] However, given the arduous process of changing a curriculum, along with barriers such as lack of time and limited space for exercise implementation within physicians' practice context, resources and energy may be better directed in improving effective exercise prescription by relying on already trained and available primary care providers for this task.

Based on this study, it is apparent that the Canadian primary care system has qualified healthcare professionals—physiotherapists—with extensive knowledge on exercise whose fundamental component of daily practice includes exercise prescription.[18] In addition to the exercise curriculum offered during the PT program, the ORPAS document review from 2008-2012 demonstrates that close to 60% of students pursuing PT have exercise-based undergraduate educations (Table 3), meaning that prior to commencing graduate studies, the majority of students pursuing a degree in physical therapy have a strong exercise science foundation that they can further develop during their professional clinical training. Recognizing that PTs are extensively trained to prevent and manage various injuries that may result from exercise participation further supports PTs as potential leaders for exercise prescription within primary care.

Findings from the survey also demonstrate that PT students are exposed to established evidence-based exercise guidelines and are trained on how to prescribe exercises when working with individuals who have numerous chronic disease(s), including complex and/or multi-system impairments. Additionally, physiotherapists work within environments conducive to exercise implementation with equipment and personnel to ensure monitoring, progression, and maintenance of an appropriate exercise program.[18] From the three primary care providers assessed in this study, it is concluded that physiotherapists are best prepared to prescribe exercise(s) to aid chronic disease prevention and management within the primary care context.

Previous researchers[19] have shown elderly people and those with chronic disease often rely on publicly funded PT services in the community. However, only 6.4 full-time PT's were employed by Ontario's 54 community health centers in 2004, while family health teams did not have any physiotherapy members on their staff in 2011. [20] Additionally, physicians have highlighted that the cost of private care results in fewer referrals to PT services, despite being aware of the benefits the clients could receive from timely PT interventions.[19] Limited inclusion of PT services within primary care increases results in poor access to physiotherapy for those that often needed it most (i.e., elderly and individuals with chronic disease). Yet PTs are well prepared to tackle the challenge of incorporating effective exercise prescription within primary care, thus addressing a key corner stone of chronic disease prevention and management.[19] Similarly to previous research,[20] findings from this study support policy implications to increase funding for PTs in primary care to enable access to appropriate interventions for all.

Limitations and future research directions. Future researchers may want to explore formal exercise education of additional primary care or alternative healthcare providers, chiropractors, registered kinesiologists, etc. Given the recent regulation of kinesiologists in Ontario and their expanding autonomy in clinical practice with potential expansion into primary care, it would be interesting to determine what role they might play with respect to exercise prescription with individuals who are at risk or have chronic disease(s). Kinesiologists were excluded from this study because they recently (in 2013) became a regulated profession in Ontario and their role in the primary care context is yet to fully develop. For example, at the time of this study they were not providers that would receive referrals from community care access centers, who are integral to connecting appropriate healthcare providers with individuals who present with complex healthcare needs in the community, such as those living with chronic disease(s). However, their expanding role and evolution in practice will be important to study in the future.

Also, findings are not representative of every professional program offered in Canada and as such there are limitations in generalizability of the findings. Additionally, despite reported trends from several MD directors who participated from three different provinces across Canada, caution must be taken in interpreting findings with respect to medical schools due to the low response rate.

The survey takes into account one perspective (i.e., program directors) and is thus at risk of bias to that participant. Additionally, student perspectives were not assessed in this study, but are worth exploring in the future, as it would be valuable to determine whether students and/or recent graduates feel that the exercise curriculum offered in their respective professional programs is sufficient and if it translates well when prescribing exercise in clinical practice.

Finally, RNs and PTs from various practice contexts should also be evaluated to determine their confidence in prescribing exercise with individuals presenting with chronic disease(s). Although, previous researchers[21] have evaluated family physicians' confidence with exercise prescription, to our knowledge RN's and PT's have not been included in such evaluation.

Conclusion

Several novel conclusions emerge from this study. First, arduous curriculum changes in medical or nursing schools to include exercise prescription may be an inefficient use of resources, given that physiotherapists are already primary care providers with extensive formal exercise education. Second, physicians and nurses should advocate for exercise and refer individuals to PTs for detailed exercise prescription to address chronic disease prevention and management. Third, policy changes are needed to ensure physiotherapists are integral members of chronic disease prevention and management teams, such as family health teams, to enable exercise prescription benefits for all. Therefore, we propose that physiotherapists ought to lead the exercise prescription movement in primary care for the purpose of chronic disease prevention and management, with MDs and RNs participating as exercise advisors or facilitators.

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Chapter 3: Exercise Prescription Considerations for Individuals with Multiple Chronic Diseases: Systematic Review

Introduction

In Canada 41% of patients have at least one chronic disease while 6% have three or more chronic diseases.[1] According to the World Health Organization,[2] chronic diseases are the leading causes of death worldwide, while in Canada 67% of deaths each year are due to cancer, diabetes, respiratory, and cardiovascular conditions.[3] Overall, hypertension is the most prevalent chronic disease followed by depression, osteoarthritis, diabetes mellitus, asthma, chronic obstructive pulmonary disease (COPD), and finally coronary artery disease (CAD).[1] Exercise has been shown to improve chronic disease management and function, decrease pain, and reduce morbidity and mortality.[3-8] To take advantage of these benefits, exercise guidelines for the general population, as well as for individuals with specific chronic diseases have been standardized. The aim of this systematic review was to determine specific overlapping physiological and subjective markers that could be used by clinicians to determine safe exercise prescription for individuals with multiple chronic diseases. For the purposes of this review, physiological markers are those that can be objectively measured by a clinician indicating a physiological change in the body, while subjective markers are reported by the individual before, during or after exercise. In this way, a personalized guideline could be determined for people with multi-system involvement in order for clinicians to provide objective and systematic exercise prescription for these individuals.

Numerous exercise guidelines[4,6-14] have repeatedly highlighted the importance of tailoring exercise on an individual basis to ensure a safe and appropriate activity program is implemented. However, none have provided specifics on *how* this could be done effectively, taking into account the complexity of health conditions experienced by individuals living with chronic diseases. The major recommendation from most guidelines is to see your “physician or healthcare provider”, which assumes that your specific healthcare provider has the appropriate knowledge and training to develop and implement an individually tailored exercise program. However, as discussed in chapter 2 of this thesis lack of time and limited knowledge have repeatedly emerged from the literature as barriers for physicians to prescribe exercise to individuals.[15-18] Given that current exercise guidelines are designed for the general/healthy population or geared towards those living with a single chronic disease, there is limited guidance to ensure safety with exercise prescription for individuals living with more than a single disease.

Therefore, despite the availability of general exercise guidelines for individuals with one chronic disease, people with multiple conditions tend to receive exercise prescription based on non-objective measures and clinical reasoning as opposed to standardized protocols.[5] Physiotherapists (PTs) commonly develop exercise protocols for clinical populations, which often include individuals living with chronic diseases. Currently, they acquire medical histories from patients and then develop individualized exercise programs in the absence of disease-specific contraindications. For instance, the recommended exercise guidelines for patients with type 2 diabetes (T2DM) include 30 minutes of aerobic activity, 5 times per week.[6-8,10,13] Contraindications to exercise for patients with type 2 diabetes include severe autonomic neuropathy, severe peripheral neuropathy, and pre- or proliferative retinopathy.[13] Similar exercise guidelines exist for patients with coronary artery disease (CAD) and chronic obstructive pulmonary disease (COPD), including recommendations of at least 150 minutes of aerobic exercise per week for patients with CAD,[9,11,12,14] and 30-60 minutes of aerobic exercise at least 3 times a week for patients with COPD.[19,20] Contraindications to exercise for patients with CAD include unstable angina, uncontrolled arrhythmias, heart failure, stenotic/uncompensated valves, and hypertrophic obstructive cardiomyopathy.[9,21] Current contraindications to exercise for patients with COPD consist of severe hypertension, hypoxemia with a drop of oxygen saturation below 85%, uncontrolled angina, or congestive heart failure.[19] This review attempts to extrapolate key physiological markers from multiple systems in the body, based on leading chronic diseases, in order to begin addressing the *how* of individualized exercise prescription. If safe ranges of key physiological markers are identified from each system in the body, clinicians can then begin to have concrete markers they can monitor to ensure safe exercise programs are implemented on an individual basis. Also, this *systems-based approach* to exercise prescription might enable tailored programming for individuals with multiple chronic diseases. This is a worthwhile endeavour, given that over half of the population living with a chronic condition have more than one disease.[22]

For this review, three of the seven most common chronic diseases in Canada were chosen for investigation, from three different body systems: coronary artery disease (cardiovascular system), chronic obstructive pulmonary disease (respiratory system), and type 2 diabetes (endocrine system). These three diseases were chosen in the attempt to identify disease-specific physiological markers that could indicate a contraindication to exercise. This systems-based approach can be further developed in the future by extrapolating key markers from many other diseases to enable a more encompassing system for exercise prescription

Methods

Studies were identified from eight electronic databases: CINAHL, PubMed, MEDLINE, EMBASE, SCOPUS, Cochrane, AMED and Pedro. These databases generated MESH terms based on the following keywords: coronary artery disease (CAD), chronic obstructive pulmonary disease (COPD), diabetes mellitus/diabetes, contraindication, adverse, risk, treatment, testing, training, physical activity, exercise, guideline, recommendation. These search terms were entered into the databases using an appropriate combination of “OR” and “AND” (see Appendix D for a search history sample). In order for the articles to be included in this systematic review, the inclusion and exclusion criteria (Table 4) needed to be satisfied:

Table 4: List of inclusion and exclusion criteria

Inclusion Criteria	**Exclusion Criteria**
· Participants must be over the age of 18 · Paper must include the disease searched · Must be human subjects · Either aerobic or strengthening exercise was administered to the patient · Must have an appropriate physiological or biological outcome measure · Must be English · Must be a guideline, systematic review, meta-analysis or randomized control trial	· Combined chronic conditions (e.g., Cancer **and** Cerebrovascular Accidents) • *Goal: extrapolate key physiological markers per system; combining systems at onset prevents achievement of goal.* · Outcomes of disease processes (e.g., MI and Heart Failure) · Neuromuscular, Neurological, Gastrointestinal, Psychological, Nephrological and Excretory Conditions: • *Not in the upper most prevalent disease states* · Acute/non-chronic disease states

The aforementioned inclusion and exclusion criteria were developed in order to obtain the most recent (last 10 years), scientifically rigorous (e.g., RCTs) evidence. Various review articles, commentaries, and case-studies that did not satisfy the inclusion criteria were used to inform the introduction and the discussion sections of this paper. The search was conducted from June 1, 2013 to December 1, 2013. The objective of this review was to identify the effects of exercise on key physiological markers that could result in death if not maintained in their safe range.

Both COPD and T2DM are the leading causes of death in chronic respiratory and endocrine disease states respectively. T2DM was chosen over type 1 diabetes mellitus (T1DM), because it is more prevalent and it can be controlled with exercise and diet, whereas T1DM must be controlled with insulin injections. The leading cause of death for the cardiovascular system is myocardial infarction, which was not included as it is an outcome of other disease states not a chronic disease in and of itself. As such, CAD—a chronic disease where the major blood vessels (i.e., arteries) that supply the heart with blood, oxygen, and nutrients become damaged—was selected for the cardiovascular system. With CAD, damage to the arteries often results from deposits, known as plaques, which lead to narrowing and/or inflammation of these vessels, thus impeding proper blood flow to the heart. Some of the common consequence of CAD can include chest pain (angina), shortness of breath, and a heart attack (death of cardiac tissue).

Outcome Measures. Outcome measures in this review include: 1) physiological markers such as heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), respiratory rate (RR), peripheral capillary oxygen saturation (SpO_2) and blood glucose, and 2) subjective markers such as the rate of perceived exertion (RPE) and the Borg Scale reviewed for each disease state. These markers were chosen as a way to monitor physiological and subjective changes that can occur during exercise.

Data Collection and Analysis. After keyword searches were completed, all duplicate articles were eliminated using RefWorks software. Next, article titles and abstracts were screened (JK-CAD, DB-COPD, AVV-T2DM, FM-T2DM) based on the inclusion and exclusion criteria. Then, two authors independently reviewed full-text articles, and selected papers were compared based on the inclusion and exclusion criteria. Reviewers (JK, AVV) analyzed all COPD and CAD articles and reviewers (DB, FM) analyzed all diabetes articles. Discrepancies between articles selections were decided or clarified by a third party (JK, DB). Finally, remaining articles were then reviewed for data extraction. Furthermore, NH was instrumental throughout the entire research process. Specifically, NH supervised the team, developed the research question, collaborated with the team to establish the search strategy, created a data extraction template, and provided extensive feedback to ensure the literature review was finalized and published within a peer reviewed journal.

See Figure 2 for a detailed overview of the article selection process. The following data were extracted from the selected studies: 1) characteristics of the exercise interventions, including: type, frequency, intensity, and duration; 2) characteristics of the outcomes: physiological or subjective outcome measures.

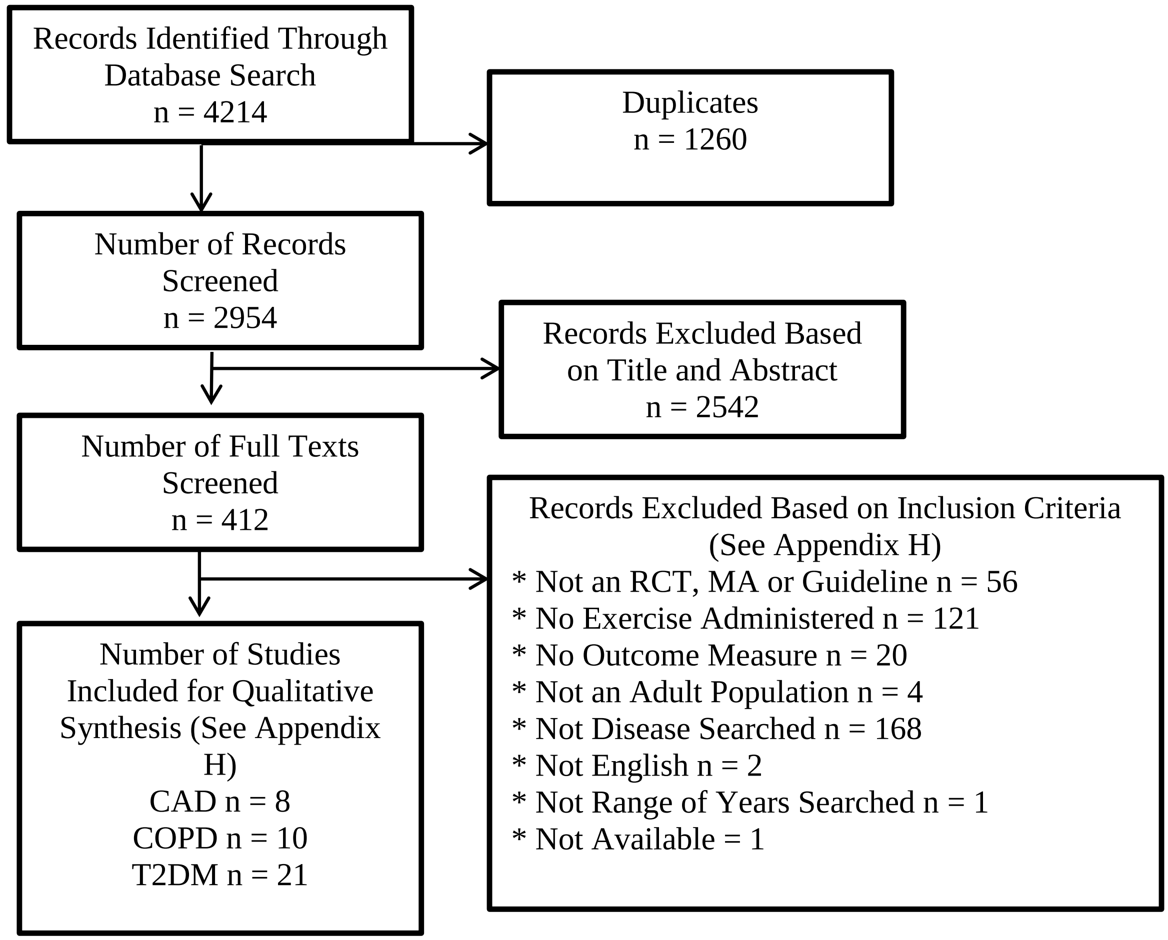

Figure 2: Article Selection Process. CAD: coronary artery disease; COPD: chronic obstructive pulmonary disease; T2DM: type 2 diabetes mellitus; RCT: randomized control trial; MA: meta-analysis.

Results

Based on the review of the literature, it is recommended that individuals living with chronic diseases should engage in aerobic, resistive or a combination of both of these types of exercises. Specific exercise recommendations, as well as contraindications and/or precautions are summarized below within appropriate tables.

Table 5: Exercise recommendations for aerobic training (AT)

	Frequency	**Intensity**	**Time**	**Type**
T2DM	Every day		10,000 steps	AT – walking[23]
			150 minutes per week	AT[24]
	5 days per week		30 minutes per day	AT[25]
		1000 Kcal per week		AT[26]

			150 minutes per week	AT – treadmill[7]
	5 days per week		20 to 30 minutes	AT- treadmill[8]
	4 days per week	moderate	3 miles	AT[27]
	3 days a week	moderate	50 minutes	AT[28]
	5 days a week	75% VO_2 max	30 to 40 minutes	AT – cycling[29]
	3 to 4 days a week	50% to 70% VO_2 max	150 minutes per week	AT[30]
CAD	Most to all days of the week	Moderate	30 minutes per day	AT[9]
	3 to 6 days per week	12 to 14 Rating of Perceived Exertion	30 to 60 minutes	AT[11]
	2 to 5 days per week	70% to 95% VO_2max	30 to 60 minutes	AT[31]
COPD		60% to 80% of symptom onset	20 minutes	AT[32]
	4 days per week	7 to 34 Watts		AT – cycling[33]
	2 to 3 days per week	75% to 80% peak workload, 40 Watts	2 to 15 minutes	AT – cycling[34]
	2 to 3 days per week	80% maximum workload	30 to 60 minutes	AT[20]

Recommendations for aerobic training (AT) (see Table 5) have emerged throughout the research for individuals with chronic diseases. For individuals with T2DM, multiple studies have shown that accumulating 150 minutes a week of moderate (40% to 60% VO_2 maximum) to vigorous (60 to 90% VO_2 maximum) physical activity is recommended.[7,8,24,25,28,30] For individuals with T2DM, 30 to 40 minutes of cycling per day, 5 times per week, at an intensity of 75% of VO_2 maximum is recommended.[29] In 2011, Araiza and colleagues[23] found that it is safe for an individual with T2DM to walk 10,000 steps per day monitored using a pedometer.

Recommendations for individuals with CAD vary between researchers. Briffa and colleagues found that aerobic exercise may be performed most days of the week for 30 minutes at a moderate intensity.[9] Similarly Pavy and colleagues recommend aerobic exercise 3 to 6 days a week for 30 to 60 minutes, while maintaining a rate of perceived exertion (RPE) between 12 and 14.[11] In a 2011 systematic review, Cornish and colleagues found that individuals with CAD are able to perform aerobic exercise 2 to 5 days per week for 30 to 60 minutes, at an intensity of 70 to 95% VO_2 maximum.[31]

Furthermore, research has determined that individuals with COPD are also able to safely participate in aerobic training (AT). Sharma and Singh[20] found that those with COPD are able to participate in AT 2 to 3 times per week for 30 to 60 minutes, working towards a goal of 80% workload cycling or on a treadmill. These results were similar to those of Nonoyama and colleagues,[34] who recommend 2 to 3 sessions per week of cycling for 15 minutes, at 75% to 80% peak workload while Corbridge and colleagues[32] recommend 20 minutes at an intensity that is 60% to 80% of symptom onset (e.g., dyspnea and fatigue). If the individual with COPD prefers cycling, it is safe to cycle at an intensity of 7 to 34 watts, performed 4 times a week.[33]

Table 6: Exercise recommendations for resistance training (RT).

	Frequency	**Intensity**	**Time**	**Type**
T2DM	3 days per week		10 repetitions	RT[35]
CAD	2 to 3 days per week	30% to 60% maximum voluntary contraction	1 to 2 sets, 5 to 15 repetitions	RT[21]
		12 to 14 Rating of perceived exertion	8 exercises, 1 set, 10 repetition	RT[36]
COPD		50% one repetition maximum	3 sets, 10 repetitions, progressing to 3 sets of 15 repetitions	RT[37]

Compared to research completed on AT or a combination of AT and resistive training (RT) for individuals with chronic diseases, few research studies have been conducted looking at the effects of RT alone for chronic disease (see Table 6). For individuals with T2DM it is recommended RT occur 3 days per week, completing 10 repetitions per major muscle group.[35]

For individuals with CAD, Bjarnason-Wehrens and colleagues[21] recommend 1 to 2 sets with 5 to 15 repetitions per set at an intensity of 30% to 60% maximum voluntary contraction. DeJong and colleagues[36] recommend RT at an intensity of 12 to 14 RPE, completing 1 set with 10 repetitions of each of the 8 exercises (i.e,. leg press, latissimus dorsi pull down, military press, lateral row, chest press, triceps press, biceps curl, and leg extension).

Recommendations for RT for those with COPD are limited to one study. Costi and colleagues[37] recommend performing upper extremity exercises (e.g., shoulder abduction, deltoid lift in the scapular plane, behind head triceps press, bicep curls at 90 degrees shoulder abduction and bicep curls) at an intensity of 50% of one repetition maximum weight, starting at 3 sets of 10 repetitions. When the individual rates the difficulty as 3 on the Borg scale, then the repetitions are increased to 12, then again to 15. Subsequently, once an individual reaches level 3 on the Borg RPE 0-10 scale while completing 3 sets of 15 repetitions, resistance is increased by 500 grams and the exercise cycle is repeated.

Table 7: Exercise recommendations for combined aerobic and resistance training. AT: aerobic training; RT: resistance training.

	Frequency	**Intensity**	**Time**	**Type**
T2DM		AT – 55% to 70% VO_2 max RT- 60% one repetition maximum		AT and RT[38]
	AT – 3 days per week RT- 2 days per week	AT – 40% to 60% VO_2 max RT – 50% to 80% one repetition maximum	AT – 150 minutes per week	AT and RT[6]
		AT – 60% to 85% VO_2	AT – 15 to 75 minutes	AT and RT[39]

		max or maximum heart rate RT – 60% to 80% one repetition maximum	per day	
	3 days per week	AT – moderate or vigorous RT – weight should not be able to be lifted more than 8 to 10 times	AT – 150 minutes per week RT – 3 sets, 8 to 10 repetitions targeting all major muscle groups	AT and RT[40]
	3 days per week	AT – 40% to 60% VO_2 max or 50% to 70% maximum heart rate RT – moderate (50% to 74% one repetition maximum) to high (75% or higher of one repetition maximum)	AT – 150 minutes per week RT – 1 to 3 sets, 8 to 15 repetitions	AT and RT[13]
	2 days per weeks	AT – 50% to 79% maximum heart rate RT – 30% to 50% one repetition maximum	RT – 1 set, 8 to 10 repetitions	AT and RT[41]
	3 days per week	AT – 65% to 85% heart rate reserve	AT – 40 to 60 minutes RT – 6 to 8 repetitions, 8 different muscle groups	AT and RT[42]
	5 days per week	AT - 40% to 70% VO_2 max RT - 50% to 74% one repetition maximum	30 to 90 minutes per day	AT and RT[43]
	3 to 5 days per week	AT – 40% to 80% heart rate reserve RT – moderate to high	AT – 150 minutes per week RT – 8 to 12 repetitions	AT and RT[44]
	AT – 3 days per week RT – 2 days per week	AT – 40% to 60% VO_2 max RT – moderate to vigorous	AT – 150 minutes per week RT – 3 to 4 sets of 5 to 10 exercises, 10 to 15 repetitions	AT and RT[45]
CAD	AT – 5 to 7 days per week RT – 2 to 3 days per week	AT – 60% to 70% VO_2 max RT – 30% to 60% maximum voluntary contraction	AT – 20 to 60 minutes per day RT – 1 to 3 sets, 8 to 12 repetitions	AT and RT[12]
	AT – 3 to 5 days per week RT – 2 to 3 days per week	AT – 40% to 60% heart rate reserve RT – 30% to 70% one repetition maximum	AT – 30 to 60 minutes per day	AT and RT[14]
COPD	AT – 3 days per week RT – 2 to 3 days per week 1 to 7 days per week	AT – 60% to 80% maximum workload RT – 50% to 80% one repetition maximum 50% maximum to maximum tolerable	RT – 1 to 4 sets, 6 to 12 repetitions 15 to 45 minutes per day	AT and RT[19] AT and RT[46]

Research into chronic disease and RT has mostly occurred in combination with

AT (see Table 7). The majority of the studies investigating T2DM and a combination of AT and RT provided the same recommendations for AT as the studies looking at AT alone: 150 minutes of AT per week at moderate (40% to 60% VO_2max) to vigorous intensity (60% to 90% VO_2max).[6,13,40,44,45] Sigal and colleagues[13] recommend that in addition to 150 minutes of AT per week, individuals with T2DM should perform RT for 1 to 3 sets of 8 to 15 repetitions at moderate (50% to 74% one repetition maximum) to high (75% or higher one repetition maximum) intensity, 3 days per week, similar to the findings of Praet and Van Loon[40] who recommend 3 sets of 8 to 10 repetitions at a weight that cannot be lifted more than 8 to 10 times, 3 days per week, targeting all major muscle groups. Weltman and colleagues[44] suggest similar RT intensity (moderate to vigorous) and repetitions (8 to 12) but recommend RT 3 to 5 days per week in combination with AT. Whyte and colleagues[45] recommend that in addition to regular AT, RT should include 3 to 4 sets of 10 to 15 repetitions at moderate to vigorous intensity, 2 days per week, while completing 5 to 10 exercises targeting major muscle groups. Colberg and colleagues[6] recommend 5-10 RT exercises targeting major muscle groups, with 10 to 15 repetitions per exercise completed at moderate to vigorous intensity, 2 days per week. They further recommend coupling RT with 150 minutes of AT per week.

Other recommendations for individuals with T2DM include AT at 55% to 70% VO_2 maximum and RT at 60% of one repetition maximum,[38] which is similar to Hills and colleagues[39] who recommend 15 to 75 minutes of AT per day at an intensity of 60% to 85% VO_2 maximum, and RT at 60% to 80% of one repetition maximum. Waryasz and McDermott[43] recommend 30 to 90 minutes of AT per day for 5 days a week at an intensity of 40% to 70% VO_2 maximum, and RT at 50% to 74% of one repetition maximum, whereas Stewart and colleagues[41] recommend AT 2 days per week, at an intensity of 50% to 79% maximum heart rate, and RT at 30% to 50% of one repetition maximum, with 1 set of 8 to 10 repetitions per exercise. In addition, Sukula and colleagues[42] recommend AT and RT, 3 days per week. Specifically these authors recommend AT for 40 to 60 minutes at 65% to 85% of heart rate reserve and 6 to 8 repetitions of RT for each of the 8 different exercises (e.g., seated leg press, knee extension, knee flexion, chest press, latissimus dorsi pull-down, overhead press, biceps curls, and triceps extension).

There are a limited number of studies providing RT and AT recommendations for people with CAD. Vanhees and colleagues[14] recommend AT occurs 3 to 5 days per week for 30 to 60 minutes, at 40% to 60% of heart rate reserve and RT 2 to 3 days per week, at 30% to 70% of one repetition maximum. Perez-Terzic and colleagues[12] recommend AT occurs 5 to 7 days per week, for 20 to 60 minutes at 60% to 70% of VO_2 maximum and RT 2 to 3 days per week, at 30% to 60% of a single maximum voluntary contraction, completing 1 to 3 sets of 8 to 12 repetitions.

Individuals with COPD can also benefit from a combination of AT and RT. Eves and Davidson[19] recommend AT 3 days per week at 60% to 80% of maximum work load and RT 2 to 3 days per week, with 1 to 4 sets of 6 to 12 repetitions, at 50% to 80% of one repetition maximum. Finally, Gutpa and colleagues[46] recommended AT and RT occur 1 to 7 days per week, for 15 to 45 minutes per day, between 50% and maximum tolerable intensity.

Table 8: Physiological marker recommendations.

	Physiological Marker	**Safe Levels**
T2DM	Blood Glucose (mg/dL)	100 to 300[6,44]
		70 to 300[35]

		> 100[13,30]
	Blood Pressure (systolic/diastolic mmHg)	< 260/155[29]
		Systolic < 200 mmHg if diabetic neuropathy present[13]
CAD	Blood Pressure (systolic/diastolic mmHg)	<160/100[21]
		90 to 180/60 to 100[9]
		Systolic < 160[11]
	Heart Rate (beats per minute)	10 bpm below angina threshold[11,12]
COPD	Heart Rate (beats per minute)	131 to 142[47]
		79.7 to 93.9[37]
		125 to 130[34]
		131 to 134[48]
	Blood Pressure (systolic/diastolic mmHg)	195 to 210/93 to 101[47]
		187 to 197/87 to 94[34]
	Respiratory rate (breaths per minute)	20.9 to 21.9[37]
		30 to 34[34]

When investigating physiological markers and exercise for individuals with chronic disease, there are multiple markers that should be monitored (see Table 8). Blood pressure is one that ought to be monitored in those living with T2DM, CAD, and COPD. For individuals with T2DM, Riddell and Burr[29] recommend keeping systolic blood pressure less than 260 mmHg and diastolic blood pressure below 155 mmHg, while Sigal and colleagues[13] recommend systolic blood pressure be kept below 200 mmHg for individuals with diabetic neuropathy. Blood glucose level is another marker that needs to be monitored with T2DM. The most common recommendation for blood glucose is to keep it between 100 and 300 mg/dL,[6,44] or above 100mg/dL.[13,30] Although Misra and colleagues recommend below 300 mg/dL for blood glucose levels, they were the only researchers to recommend that it is safe to exercise with blood glucose as low as 70 mg/dL.[35]

Blood pressure also needs to be monitored in individuals with CAD. Bjarnason-Weherns and colleagues[21] recommend that systolic blood pressure be below 160 mmHg and diastolic blood pressure be below 100 mmHg, which is similar to the results of Pavy and colleagues[11] (systolic blood pressure below 160 mmHg). Briffa and colleagues[9] recommend systolic blood pressure be between 90 and 180 mmHg, with diastolic pressure between 60 and 100 mmHg. Individuals with CAD should also have their heart rates monitored and it is recommended that the heart rate should not go above 10 beats per minute below an individual's angina threshold.[11-12]

Blood pressure is also imperative to monitor for individuals with COPD. Bradley and O'Neill[47] recommend systolic blood pressure be between 195 and 210 mmHg and diastolic blood pressure be between 93 and 101 mmHg, which is similar to Nonoyama and colleagues[34] who recommend a systolic blood pressure between 187 and 197 mmHg and a diastolic pressure between 87 and 94 mmHg. Several researchers[34,37,47,48] have found safe ranges for heart rate for individuals with COPD. Nonoyama and colleagues[34] recommend 125 to 130 beats per minute, similar to both Bradley and O'Neill[47] who recommend 131 to 142 beats per minute, and Zainuldin and colleagues[48] (131 to 134 beats per minute). Costi and colleagues[37] have the lowest recommendation for heart rate at 79.7 to 93.9 beats per minute. Respiratory rate for individuals with COPD varies, with Costi and colleagues[37] recommending between 20.9 and 21.9 breaths per minute, and Nonoyama and colleagues[34] recommending 30 to 34 breaths per minute.

Table 9: Contraindications and precautions to exercise.

T2DM	Contraindications	Avoid exercise if blood glucose is greater than 300 mg/dl or less than 70 mg/dl[35]
		If fasting blood glucose is greater than 15 mmol/L and ketones are elevated, no vigorous activity until glucose is under control[29]
		Severe autonomic neuropathy, severe peripheral neuropathy, proliferative retinopathy[13]
		If non- or proliferative retinopathy is present, no heavy weightlifting[41]
		No exercise if ketosis is present and if a person has retinopathy, vigorous RT and AT should be avoided.[44]
	Precaution	Patient should be adequately hydrated if glucose levels are 300 mg/dl (16.7 mmol/l). If taking insulin, carbohydrates should be ingested when blood glucose is less than 100 mg/dl (5.5mmol/l).[6]
		Temperature elevation of 4°F compared to the opposite foot may be a marker of inflammation and increased risk of ulceration.[8]
		If severe peripheral neuropathy, non-weight bearing activities like

		swimming, bicycling or arm exercises should not be used.[35]
		Pay attention to peripheral artery disease or diabetic foot disease before starting exercise. Medication (insulin) needs to be adjusted before starting an exercise program.[28]
		Exercising at greater than 6 metabolic equivalents increases the probability of having a myocardial infarction. Vigorous activity needs to be supervised because of an increased risk for a cardiac event. For those at risk for a coronary event: warm up and cool down (10 minutes each) with 20 to 60 minutes of activity at a lower intensity. Non-weight bearing exercises are suggested for high-risk individuals.[29]
		Moderate to severe hypertension (greater than 160/100) should be controlled before starting exercise.[41]
		Prior to exercising, individuals with diabetes taking insulin may need to reduce their insulin doses and consume carbohydrates to prevent hypoglycemia. Glucose should be ingested when blood glucose is less than 100 mg/dl prior to exercising.[30]
CAD	Contraindications	Unstable angina, uncontrolled arrhythmias, heart failure, stenotic/uncompensated valves, hypertrophic obstructive cardiomyopathy.[21]
		Terminate exercise with any of the following signs: dizziness, discomfort/pain in chest, leg ache that prohibits function, physical inability to continue, palpitations, fatigue, difficulty breathing, nausea, and excessive sweating.[9]
	Precautions	Exercise should be stopped when rating of perceived exertion is 17 or higher.[49]
		Individual should be able to speak without breathlessness.[11]
COPD	Contraindications	Severe hypertension, hypoxemia, uncontrolled angina or congestive heart failure.[19]
		Angina pectoris, recent myocardial infarction, severe pulmonary hypertension, congestive heart failure, unstable diabetes, inability to do exercise due to orthopaedic conditions, severe exercise-induced hypoxemia, not correctable with O2 supplementation, and unwilling to give consent.[20]
	Precautions	Stop exercise if SpO_2 drops below 88% or a sudden drop of 2-5% from average.[50]

In terms of contraindications to exercise in individuals with multiple chronic diseases, each disease has a specific set of indicators that must be monitored to ensure safety for the individual (See Table 9). With T2DM, exercise is contraindicated and should not be performed in individuals with blood glucose level above 300 mg/dL or below 70 mg/dL.[35,29] Exercise is also contraindicated for individuals with T2DM if they have ketosis,[29,44] or severe autonomic or peripheral neuropathy.[13] For individuals with retinopathy due to T2DM vigorous AT or RT is contraindicated.[13,41,44] Individuals with peripheral neuropathy may be able to safely perform non-weight bearing activities like swimming or cycling.[35]

Individuals with CAD should not exercise if they have unstable angina, uncontrolled arrhythmias, heart failure, stenosis or uncompensated valves, or hypertrophic obstructive cardiomyopathy.[21] Exercise should be terminated if the individual starts to feel dizziness, discomfort or pain in chest, leg ache that prohibits function, physical inability to continue, palpitations, fatigue, difficulty breathing, nausea and/or excessive sweating.[9]

For those individuals with COPD, exercise is contraindicated if they have angina pectoris, recent myocardial infarction, severe pulmonary hypertension, congestive heart failure, inability to exercise due to an orthopaedic condition, severe exercise-induced hypoxemia not correctable with O_2 supplementation, and/or are unwilling to give consent.[19,20]

Precautions to exercise should be considered before initiating and during participation in an exercise program (See Table 9). For individuals with T2DM on insulin therapy, to avoid a hypoglycemic event (a drop of blood sugar below 100 mg/dL) insulin may need to be adjusted[6,30] or carbohydrates may need to be consumed before starting to exercise.[6,28,30] Individuals with T2DM who exercise at an intensity of 6 metabolic equivalents (METS) are at an increased risk of myocardial infarction and need to be monitored closely when exercising. Riddell and Burr recommend that for those individuals at risk for a cardiac event (increased waist circumference, increased triglyceride levels, hypertension, advanced age, a history of smoking and a family history of CAD), a warm up and cool down of 10 minutes should be done and 20 to 60 minutes of activity at a lower intensity.[29] For individuals with uncontrolled hypertension (greater than 160mmHg SBP and/or 100mmHg DBP) blood pressure must be controlled before exercise can begin.[41] Marwick and colleagues recommend that if there is a temperature elevation of 4°F in an individual's foot when compared to the other, it may be a marker of inflammation and therefore the individual is at increased risk of ulceration.[8]

Individuals with CAD need to take precaution when exercising, as the individual should be able to perform at an intensity permitting them to speak without breathlessness[11] and exercise should be stopped when the rating of perceived exertion is 17/20 or higher[49]. For individuals with COPD, exercise should be stopped when SpO_2 drops below 88%, or if there is a drop of 2% below the average SpO_2.[50]

Individuals with multiple chronic diseases are encouraged to exercise throughout the literature, but careful precautions must be taken to ensure it is done safely. When working with individuals with different chronic diseases, each disease has its own dosage for exercise prescription and markers, as well as overlapping markers for the clinician to consider when determining a safe and effective exercise program.

Discussion

The results of this review suggest that a systems-based exercise prescription process using overlapping physiological and subjective markers may be possible. As demonstrated from various existing exercise guidelines[4,6-14], currently there is predominantly knowledge about exercise prescription taking into account for a single disease. The remaining question is how to prescribe exercise when an individual has more than one chronic disease? There are few specifics about how this can be accomplished using a systematic approach. Furthermore, guidelines often recommend speaking to your healthcare provider about a safe exercise regimen for those with chronic diseases, yet lack of time, limited knowledge and education about exercise prescription are noted barriers to this tailoring approach.[15-18] In order for individuals with chronic diseases to reap the benefits associated exercise and reduce risk of injury, safe ranges of physiological markers can be identified for clinician to guide their exercise prescription efforts.

After looking at CAD, T2DM and COPD for the cardiovascular, endocrine and respiratory systems respectively there is evidence of overlapping markers that clinicians could use to determine safe exercise limits for individuals with chronic conditions. The most commonly overlapping markers across all three systems included SBP, DBP, RPE and HR.

Each chronic disease has unique contraindications to exercise. As such, with this proposed system when the health care provider is first considering exercise for an individual all of the contraindications listed in the results[9,13,19-21,41,44] must be cleared. If an individual has a chronic disease then contraindications unique to that disease must be cleared. This means that when an individual comes in with multiple chronic diseases, all contraindications to exercise must be cleared for all disease that are present. Given the complexity multiple chronic diseases can present, it is not surprising that one of the main reasons physicians often lack confidence with exercise prescription is due to limited knowledge.[51] This stresses the importance of a system that can simplify the exercise prescription process while also emphasizing the importance of contraindication clearance.

Furthermore disease specific markers can be monitored. For instance, COPD which represents the respiratory system, has a unique SpO_2 marker that should be kept above 90% in order to ensure body tissues adequately oxygenated,[19,34,37,47] while individuals with CAD, representative of the cardiovascular system, must keep HR 10 beats per minute below the threshold of angina symptoms.[11,12] The HR staying below this threshold gives the health care professional confidence that there is very little risk that a cardiac event will occur. Lastly, individuals with T2DM representing the endocrinology system, must have their blood glucose levels between 100 and 300 mg/dLin order to prevent any serous symptoms while exercising.[6,13,35] These examples clearly outline defined ranges of physiological markers that can be measured to determine appropriateness and safety of exercise.

Furthermore, this review portrays an emerging pattern of overlapping physiological and subjective markers that could be used by clinicians to guide safe exercise. For the three system-based diseases investigated, there were overlapping markers between them. Blood pressure has been suggested for assessment and monitoring for T2DM, CAD and COPD. Findings from articles on all three diseases suggest keeping systolic blood pressure (SBP) between 160-260 mmHg and diastolic blood pressure (DBP) between 94-155 mmHg to ensure safety during exercise.[21,29,31,47] For individuals with COPD and CAD, it is imperative to monitor HR, with safe limits ranging from 79.7-142 bpm for those with COPD [34,37,47,48] and 10 bpm below angina threshold for those with CAD.[11-12] Maximum VO_2 is another physiological marker that was suggested in the literature as a guide for exercise intensity for people living with T2DM and CAD. For individuals with T2DM, studies recommended aerobic activity intensity should stay between 40 and 85% VO_2max.[6,13,29,30,38,39,41,43-45] Four studies recommended a range of 60-95% VO_2max for individuals with CAD.[12,14,21,31] This demonstrates that overlapping markers do exist across multiple chronic diseases, alluding to an innovative way for clinicians to prescribe and monitor safe exercise limits for individuals who have more than one disease.

One of the goals of this review was to determine whether key markers could be extrapolated for each of the cardiovascular, respiratory and endocrine systems. The three prevalent diseases presented in this review illustrate a potential way to begin extracting key physiological markers for respective body systems. For example, if an individual has either COPD or cystic fibrosis then the clinician would monitor the respiratory system and using table 10 below would know to monitor S_pO_2 and VO_2 max. To further the previous example, if a clinician is prescribing exercise to a person with an endocrine disease and a cardiovascular disease then the clinician would know to monitor SBP and DBP as they overlap between systems. This review has shown initial evidence for key markers that should be monitored for exercise prescription and ongoing assessment of the effects of exercise. See Table 10 for the initial physiological markers that this paper suggests should be monitored.

Table 10: Key physiological markers to be monitored for exercise prescription based on a body-systems approach. HR: heart rate; BP: blood pressure; VO_2 max: Maximum volume of oxygen consumption.

	Cardiovascular System	**Respiratory System**	**Endocrine System**
Physiological Markers	• HR[11,12] • BP[9, 11,21] • VO_2 max[12,14,21,31]	• S_pO_2[19, 34, 37, 47] • BP[34,47] • RR[34,37]	• Glucose [6, 13, 29, 30, 35, 44] • BP[13,29] • VO_2 max[6,13,29,30,38,39,41,43-45]

This review demonstrates the complexity of developing a system that effectively ensures safety for those with multiple chronic diseases. It reveals the possibility of key physiological markers that could be screened in each of the 11 body systems. However, the complexity of tailoring exercise programs by considering all key physiological markers form each system of the body in order to meet the needs of an individual with multiple disease is outside of the scope of this systematic review.

This review has helped further demonstrate the complexity of exercise prescription considerations for individuals living with multiple chronic diseases.

The following algorithm (Figure 3) is proposed for clinicians to consider when working with individuals living with chronic disease(s). The application starts with an individual arriving in the clinical setting for an assessment. The clinician completes a subjective assessment and records a detailed medical history. If the individual has any single chronic disease, as determined by the history, the clinician would simply follow the current best-practice guidelines for exercise prescription with regards to that disease. If however, the individual is living with more than one chronic disease (such as T2DM and CAD) then the clinician will need to consider both disease-specific contraindications to exercise with the individual (such as severe autonomic neuropathy for T2DM and unstable angina for CAD). If the contraindications are cleared, the overlapping physiological and subjective markers for the two diseases then systematically guide a safe exercise prescription for that person. Furthermore, the same overlapping markers could then guide re-assessment during the following treatment sessions for exercise progression or individualized exercise prescription changes.

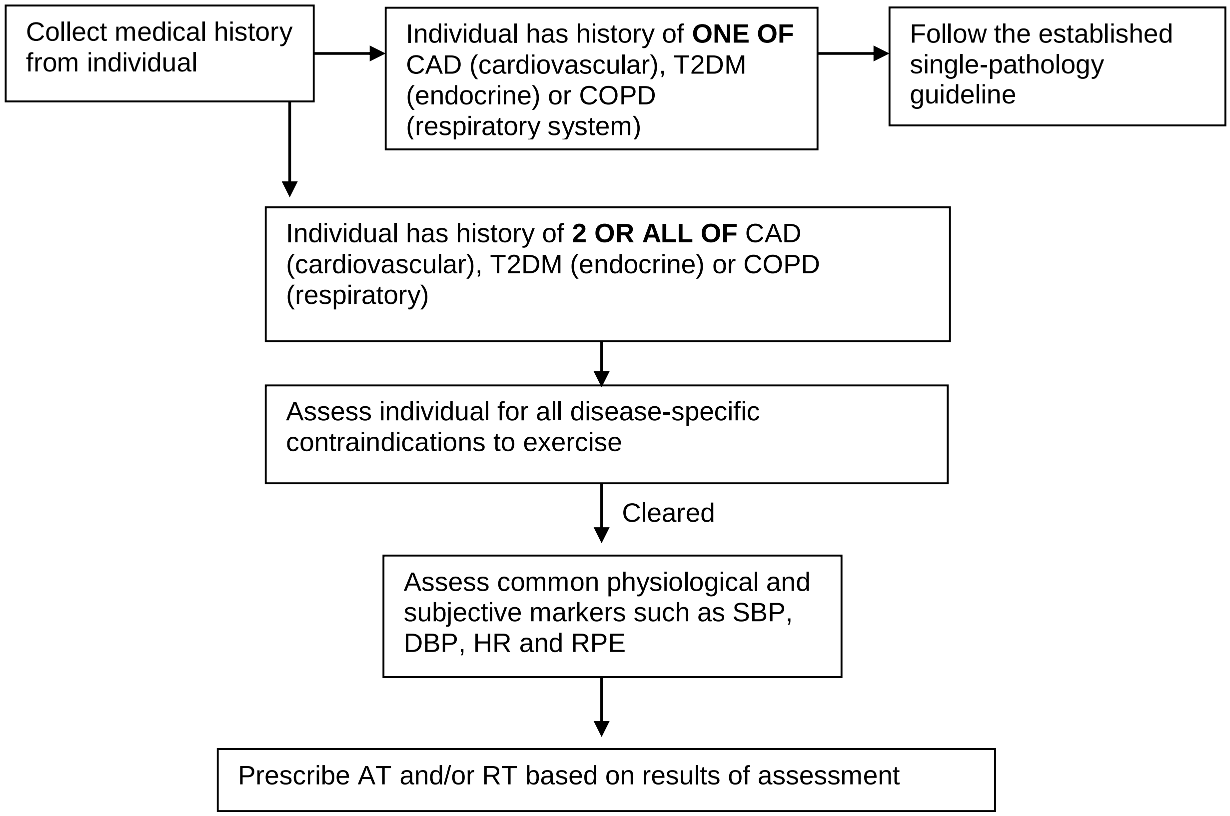

Figure 3: Exercise prescription guide for clinicians to use when working with individuals living with chronic disease(s).

The results from this review show that for COPD, the clinician has to ensure that SpO_2 levels stay above 90%,[19,34,37,47] and for CAD the individual's HR must be kept 10 beats per minute below one's angina threshold.[11,12] A limitation of this systematic review is that there are currently no physiological markers for T2DM that clinicians can monitor during exercise, since blood glucose can only be measured pre- or post exercise. This finding makes it difficult for clinicians to be confident that an individual with T2DM is not exercising in a danger zone. However, when working with people who have T2DM serious injury or death may be avoided as long as the clinician is aware of the signs and symptoms of hypoglycaemia and how to respond in case it presents. Ideally, having a physiological marker to monitor such as HR, RR, BP, or SpO_2, could prove to be more informative and pragmatic with exercise considerations rather than solely relying on biological markers (e.g., glucose).

Next, when the articles were reviewed for inclusion and exclusion from the systematic review, articles that had subjects with two chronic diseases, such as CAD and T2DM, were excluded from the study. Having these articles in the study would have confounded the generalization of the results. It would be difficult to ascertain if the results emerged due to CAD or T2DM. By the individual having two chronic diseases, the subjective, physiological and biological markers in these studies would be affected in unknown ways and the interpretation of results would be limited. It may be possible to compare the single article results with combined diseases to see if different conclusions would emerge.

This review could have been strengthened if it focused on completing a review based on all currently available systematic reviews, to ensure greater comprehensiveness covering a larger range of studies. Future researchers may want to develop a systematic review to analyze all current meta-analyses and systematic reviews to achieve a more comprehensive summary of the current knowledge of exercise prescription recommendations for individuals with multiple chronic conditions.

This review presents the initial framework for a systems-based approach to exercise prescription for individuals with CAD, COPD and T2DM. The systems approach presented in this systematic review may be applied to many other chronic diseases in the future to create a more encompassing exercise prescription. The next step for this area of research is to examine other chronic diseases such as: hypertension, depression, arthritis and cancer for subjective, biological and physiological markers that will help inform exercise prescription for clinicians.

Furthermore, future study focus can emerge from this initial attempt at a systems-based exercise prescription is to analyze each body system in isolation and extrapolate safe ranges of key physiological markers unique to that system. For instance, HR is a marker associated with the cardiovascular system, which we have identified as one of the key factors to be monitored during exercise. Glucose is a biological marker associated with the endocrine system, which we know must remain in a specified range to prevent serious consequence such as hypoglycemia and in most severe cases, death. Thus, future researchers with sufficient resources may want to begin extrapolating markers per system, rather than disease, so that we can begin to tailor programs for the whole individual regardless of the disease(s) that is present. This might be achieved by screening all of the key markers from each body system before initiating an exercise program. This approach would truly step away from the dominant single disease-driven guidelines and consider the full physiology of the person. The underlying hypothesis would be that if the key marker in each system is within the safe range, then regardless of the diseases present a safe and unique exercise program could be developed, implemented, and monitored.

Lastly, the current model of “referring to your healthcare provider for a patient-specific exercise program” is not ideal or necessarily safe for individuals living with multiple chronic diseases. This is an inadequate recommendation because it assumes that the healthcare provider has appropriate knowledge to create and implement a patient-specific exercise program. Physicians often do not have exercise science training, yet are often encouraged to take the lead in exercise prescription.[15-18] Chapter one findings suggest that PT’s may be best prepared to take on this role in primary care, but further research is required to consolidate or disprove these findings.

Conclusion

This systematic review acts as a stepping-stone for the emergence of standardized yet individualized exercise prescription, as it shows initial evidence for a multi-system approach to exercise prescription. Screening key physiological markers from various body systems in order to safely prescribe exercise to individuals with multiple chronic diseases may be possible and appropriate**.** Resistance and aerobic training exercise prescription can be safely tailored to individuals with CAD, COPD and T2DM. Disease-specific contraindications and precautions to exercise need to be recognized and discussed within the clinical practice setting. Upon assessment and throughout treatment, safe ranges of key physiological and subjective markers need to be monitored for specific exercises to be prescribed and implemented safely for individuals with or at risk of having chronic disease(s).

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Chapter 4: The *how* of exercise prescription in primary care: A proposed approach

Introduction

Primary care is the important first point of contact within the healthcare system, addressing health promotion, prevention, as well as diagnosis and treatment of illness and injury.[1] This context provides an opportunity for appropriate providers to effectively implement exercise prescription and aid efforts in chronic disease prevention and management.

Limited time and knowledge have frequently emerged as barriers for physicians and nurses to effectively prescribe exercise within primary care.[2-4] However, chapter 2 demonstrated an opportunity to potentially address these barriers by delegating the role of exercise prescription to physiotherapists (PTs). Although knowledgeable on how to safely prescribe exercises for clients within their daily practice, opportunity for vulnerable groups (e.g., individuals with chronic diseases) to access PTs and reap the benefits of exercise prescription can be limited, since a small number of PTs work within publicly funded primary care settings.[5] For example, it has been reported that from 267 hospitals in Ontario, as few as 197 had registered PTs and only 106 PTs were employed in the long term care (LTC) sector.[6] Recognizing that one PT provides coverage in five LTC facilities, where each LTC services approximately 120 residents, a single PT is expected to provide appropriate, timely, and effective care to approximately 600 residents.[6] In addition, one of the main primary care access points in Ontario includes the family health team (FHT) and until recently there were no PTs employed in FHTs. [7]

In order to begin improving access to necessary PT services, especially for the growing aging population, researchers have supported integration of PTs within primary care teams.[7] In support of this vision, as of 2013 interim funding was provided for primary care teams to apply for physiotherapist positions and target delivery of specific programs such as lung health, cardiovascular health, and healthy aging.[8] More recently, in 2014, 38.3 full time equivalent physiotherapist positions were made available in primary care organizations across Ontario. (8) These primary care organizations include: 1) family health teams (FHTs); 2) Community Health Centres (CHC); 3) Nurse Practitioner Led Clinics (NPLCs); and 4) Aboriginal Health Access Centres (AHAC). These timely changes present an opportunity for PTs to lead the exercise prescription movement by collaborating within well-established primary care teams. For instance, inclusion of PTs to prescribe exercise for chronic disease prevention and management efforts within multi-disciplinary primary care teams promotes the inclusion of a health promotion and prevention piece that has historically been excluded from the current primary care system primarily designed to respond to acute health problems.[9] This long-standing *reactive* approach cannot appropriately tackle chronic disease(s).

A specific section of the Ministry of Health and Long Term Care (MHLTC) Framework includes improving the delivery system design (i.e., the way clinical practice is organized and delivered) to meet the needs for effective care delivery and chronic disease prevention. Re-designing clinical practice for clients affected by chronic disease requires that the most appropriate provider deliver expert care, while minimizing clients' need to navigate the healthcare system alone. Given the complexity of chronic disease, effective care delivery for clients will require more than a single provider. Therefore, it is not surprising that interdisciplinary healthcare teams have shown improved care for individuals with chronic disease.[9] Inclusion of well-prepared PTs within multi-disciplinary primary care teams to incorporate health promotion and prevention efforts through appropriate and tailored exercise prescription aligns well with MHLTC's Framework to re-design the delivery system and begin addressing the complex needs of individuals with chronic disease.

Although these are positive changes, with only 38.3 full-time equivalent positions, there is an expectation for a single PT to sometimes service anywhere between 500 to 7000 patients within the primary care context.[10] Thus, the traditional one-to-one PT service delivery is limited within such a setting and creative solutions to effectively address a population level health approach are necessary.[10] That being said, special consideration is warranted for individuals with complex health needs, such as elderly with chronic diseases. In some instances, individuals will require direct and personal guidance to develop self-efficacy towards managing their health[9] and the importance of tailored exercise prescriptions designed to meet their unique healthcare needs should not be ignored, or underestimated. Recently, 12 PTs from Ontario primary care teams were interviewed and they showed that PTs play unique roles in this setting as managers, evaluators, educators, collaborators, and advocates.[11] Practice in this context often requires the PTs to push the boundaries to emphasize health promotion to meet the needs of clients within a changing healthcare landscape.[11] Therefore, creative solutions are necessary in order to facilitate evidence-informed exercise prescription for those living with chronic diseases.

In this chapter, a guide on *how* exercise prescription might be effectively implemented within Ontario's primary care context is presented, taking into account the complex needs of individuals with chronic diseases. Although some PTs report being consulted about all physical activity needs of clients in primary care settings,[11] even though they may not personally deliver exercise programs, an evidence-informed and systematic approach to guide exercise prescription for the management of multiple chronic diseases is limited.[10]

Study1 and study 2, along with previous relevant literature informed the development of a two-phase conceptual model, which was designed to help guide decision-making and achieve a systematic, evidence-informed, and client-centered exercise prescription in primary care. First, the development process is described, followed by Phase 1, which introduces the exercise screening, including the interaction that ought to occur during the first point of contact between a provider (i.e., often a nurse, or a physician) and the client. Phase 2 then presents an exercise prescription process that incorporates key factors that ought to be considered for exercise prescription with individuals living with multiple chronic diseases. The chapter is concluded by a discussion of implementation considerations, including validation of the proposed exercise prescription approach, and potential barriers to implementation.

The development of the proposed exercise prescription approach

The proposed exercise prescription approach was developed by considering the limitations of the biomedical model and incorporating the important personal, social, and environmental factors. The biomedical model has an emphasis on disease—its etiology, pathology, and clinical manifestation,[12] but it largely ignores the equally important personal and broader social determinants of health (e.g., socioeconomic status, environment, education, etc.). These equally important factors will impact one's action towards achieving health, which is defined by the World Health Organization (WHO) as a " complete state of physical, mental, and social well-being, and not merely the absence of disease".[13] The proposed exercise prescription approach was thus informed by the 5 A's model,[14] findings from chapter 1 and chapter 2 of this thesis, established exercise guidelines,[15] WHO's definition of health,[13] as well as previous literature on client-centered care[16] and health promotion.[17]

The first phase of the exercise prescription approach introduces the screening that ought to be completed by the first-point of contact clinician, which is often a nurse or a physician within the primary care context. Although, previous researchers have called upon physicians[18-20] and nurses[21,22] to incorporate exercise prescription into their daily practice, limited knowledge and time consistently emerge as barriers for these clinicains.[2,4,22] On the other hand, study 1 and previous literature[18,21] suggest that these providers are in a position to counsel, facilitate, or advocate for exercise. Therefore, primary care physicians and nurses are in a position to guide clients through Canada's healthcare system towards appropriate care to reap the benefits of exercise.

With this realization, the 5 A's model, (comprised of the elements: ask, advise, assess, assist, and arrange) initially and effectively used by nurses and physicians in tobacco cessation efforts within primary care,[14] was modified and adapted to help guide first-point of contact clinicians through the exercise screening process. Sweeden[23] previously incorporated a version of the 5A's model in their practice context to guide providers with exercise counseling, which further helped inform the development of the 5A's model in the exercise screening phase proposed in this chapter. Details of the 5 A's model for the purpose of exercise screening are presented in the section entitled "Phase 1: the exercise prescription screening phase".

A key aspect discussed in greater detail within the second phase of the proposed exercise prescription approach, introduces a conceptual tool that accounts for important physiological factors that should be considered in order to ensure safety when developing an exercise prescription for those affected by chronic diseases. Inclusion of this aspect of the proposed exercise prescription approach was partially informed by study 2 of this thesis and previously established exercise guidelines.[15] Specifically, focusing on the contraindications to exercise and key physiological markers that need to be monitored in order to inform an exercise prescription (i.e., exercise frequency, intensity, type, and time/duration). This physiological profile component of the exercise prescription tool has roots in the biomedical model,[12] as key disease-specific factors are considered for this screen to ensure safety with exercise.

However, the physiological profile is only one aspect of the proposed exercise prescription tool. Another key component incorporates a personal profile, comprised of elements such as individuals' activity preferences, economic means to participate in exercise, transportation mode, environmental considerations, and other personal factors, which are proposed as important for consideration when developing the initial exercise prescription. The decision to include personal factors in the initial exercise prescription was informed in-part by considerations of the International Classification of Functioning, Health and Disability model and the Institutes of Medicine's enabling-disabling process model,[12] which recognize that a person's participation in activities may be influenced by the person, as well as their physical and social environment.

Finally, another fundamental component of the exercise prescription approach includes clinical reasoning and collaboration with the client. This clinician-client interaction helps modify the tool's initial exercise prescription in order to develop a truly tailored program that is relevant and meaningful to the person's life context. This is a fundamental component, as it ensures that the client is central during the exercise prescription development process. Therefore, the final tailored exercise prescription is an outcome from the agreement reached between the clinician and the client, informed by the client's physiological and personal factors, clinical reasoning, and client's feedback/collaboration. In other words, the content of the final exercise prescription (paper or digital copy) is created *with* the client, not something that is simply given *to* the client.

The decision to provide a copy (e.g., paper or digital) of the exercise prescription was informed by previous evidence, which showed that providing an exercise prescription or a specific printout led to better compliance[24] and a 15-50% increase in physical activity.[25] Thus, in addition to the physiological profile and disease-specific safety considerations that largely stem from the biomedical model, broader concepts of health (i.e.,WHO's definition,[13] IFC and The Institutes of Medicine's enabling-disabling process model[12]), health promotion (i.e., enabling individuals to take control over their own health[17]) and client-centered care literature[16,26] (i.e., the client is a well-informed and active participant in decisions regarding their health) all provided key building blocks that helped inform the foundation of the proposed exercise prescription approach.

Being aware of the background that informed the development of the proposed approach enables the reader to recognize how each phase of the proposed model was conceptualized. The following sections provide details of each phase that comprise the overarching conceptual exercise prescription approach proposed in this chapter.

Phase 1: The exercise prescription screening phase

In primary care an individual's first point of contact will often be with a physician (MD) or a nurse (RN). With respect to exercise prescription, previous research[2,22,27,28] and chapter 2 from this thesis indicate that neither of these professionals is formally prepared to prescribe an appropriate exercise program. However, RNs, MDs, and PTs were all identified as being well prepared to counsel clients regarding the benefit of exercise.[18,22,29] Thus, all of these clinicians can participate as exercise facilitators, or advocates to help with chronic disease management efforts.

An established 5 A's model for smoking cessation has been used in public health and primary care.[14,30] The 5 A's model is comprised of five key elements, including: Ask, Advise, Assess, Assist, and Arrange. Given the simplicity, familiarity, and its effectiveness,[14] the 5 A's are applied for the purpose of illustrating *how* the first point of contact clinician (e.g., often an MD or RN) in primary care may advocate or facilitate exercise participation. The two columns in Box 1 compare how the 5 A's model can be translated from the tobacco cessation mandate[30] to the clinicians' role in the exercise prescription screening phase.

Box 1: Application of 5A's from tobacco cessation to exercise prescription

Tobacco cessation:	**Exercise prescription screening phase:**
ASK all clients about tobacco use at every contact with all clients. *Example: "Have you used tobacco in the last 6 months"? Document tobacco use status.*	**ASK** all clients about exercise habits at every contact. *Example: "How often do you exercise?"*
ADVISE all tobacco users to consider quitting. *Example: Urge every tobacco user to quit in a way that is personally relevant.*	**ADVISE** all clients to participate in exercise. *Example: Discuss benefits of exercise and encourage every client to participate in exercise that is personally relevant.*
ASSESS tobacco users' readiness to quit *Example: ask every tobacco user if they are ready to make a quit attempt at this time. Assess how important it is for them, and how confident and ready they are to make a change.*	**ASSESS** client's readiness to start exercising *Example: Ask every client if they are ready to start an exercise program.*
ASSIST according to client readiness/stages of change *Example: help the patient make a plan to quit smoking.*	**ASSIST** according to client's readiness/ stages of change. *Example: assist the patient to make a plan to meet with PT to begin an appropriate exercise program.*
ARRANGE for referral and follow-up *Example: Smokers' Helpline, contact your local public health unit.*	**ARRANGE** for referral and follow-up. *Example: Refer client to PT for an exercise prescription: follow-up during check-up appointments how the exercise program is going for them.*

An elaboration of each section of the 5A's model is provided to further illustrate the screening phase and how this model might be operationalized within the primary care context.

Ask. The Ask component is operationalized during the first visit with a client. It determines the individual's exercise tendencies, in order to ascertain if the client requires additional support to commence an exercise program. There are several questions that may assist the clinician in determining if a client is participating in regular exercise, such as:

- Do you engage in regular exercise?
- How often do you exercise? (e.g., frequency: daily, twice per week, etc.)
- How long do you exercise? (e.g., duration: minutes per session)
- How intense is your exercise? (e.g., rate of perceived exertion)
- What do you do for exercise? (i.e., type: walking, swimming, weight-lifting, etc.)

These five questions are meant to determine if the client has a consistent exercise program and/or if they are in need of further assistance to commence exercising. If a client reports that they do not exercise, the clinician can proceed to the Advise stage of the 5 A's model and share information about the benefits of exercise with the client.

On the other hand, if a client reports already participating in exercise the first-point of contact clinician may ask follow-up questions to determine if additional supports are needed. For example, if the client shares that they have been exercising, the first-point of contact clinician may still decide to refer this client to a PT for instance to modify, or progress the client's exercise program in order to achieve additional health benefits and/or minimize risk of injury.

Advise. The key aspect of the Advise component is that the client is informed about exercise and how an exercise program leads to benefits that are important or relevant to the client. For example, if a person with diabetes and arterial insufficiency shares that they love gardening, but are no longer able to enjoy it due to increased discomfort with activity, the first-point of contact provider can discuss with this client that they might be able to enjoy gardening with an appropriately designed exercise interventions that targets key components that are currently limiting their gardening participation (e.g., back pain, lower extremity weakness, etc.). The key purpose of this stage is to inform the individual with chronic disease(s) how an appropriate exercise program could be beneficial and that there are appropriate supports to facilitate their involvement.

Assess. The Assess stage is where the clinician becomes informed about client's readiness to begin an exercise program. The Transtheoretical Model (TTM)[31-33] and the stages of change are used to illustrate how the clinician can ascertain client's readiness to commence an exercise program.

1) Pre-contemplation is the stage where a client is not ready to start exercising.
2) Contemplation is when a client is thinking about starting an exercise program.
3) Preparation occurs when a client is ready to commence an exercise program.
4) Action occurs when the client has started an exercise program.
5) Maintenance stage is when a client is exercising for six months to five years.
6) Termination occurs when a client has no risk of relapse and exercise becomes a lifestyle they no longer need to think about, such as putting on shoes when leaving your house.

In reality, the termination stage is unlikely to be reached, but maintenance may be a more realistic goal, where regular exercise becomes a component of a person's daily lifestyle, with occasional interruptions being a normal way of life (e.g., appointments getting in the way of exercise, injury or acute-illness, etc.,). The client should at least be in the preparation stage, or express that they are ready to commence an exercise program, in order to proceed to the Assist stage of the 5 A's model. Otherwise, the clinician may need to spend some time moving from Ask, Advise, and Assess components of the 5 A's model, until the client reaches TTM's preparation stage. Even after an exercise program has been arranged, during follow-up, the clinician may repeatedly need to Ask, Advise, Assist, and make new arrangements with the client. Therefore, just as the stages of change occur as a spiral, with relapse being a realistic occurrence during the change process, the 5A's are also fluid and more cyclical rather than linear in nature.

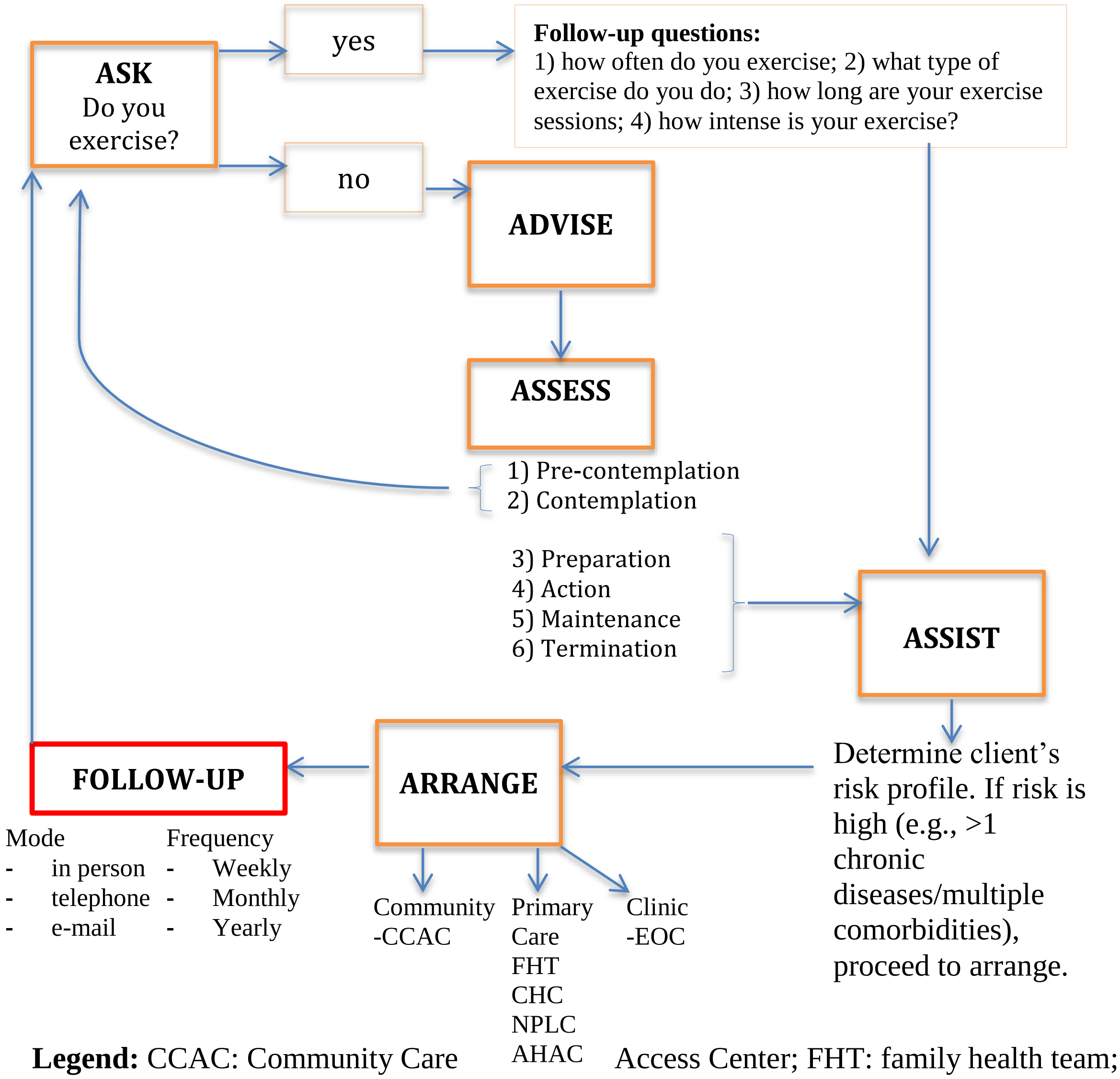
Assist. Once the client is prepared to commence an exercise program the clinician ought to determine their risk level. For instance, a client who has a well-managed chronic disease, without any complications or comorbidities, may benefit from attending a general community-based exercise program at a community center, or a fitness facility. However, for clients who have multiple diseases, arranging an appointment with a physiotherapist to develop a tailored exercise prescription may be more appropriate. Therefore, in this stage the client's risk profile is determined so that they may be appropriately assisted with navigating the healthcare system to reach the next stage where a specific action can be arranged.[9]

Arrange. Once it is determined that a client is prepared to commence an exercise program and that they require a tailored exercise prescription to meet their unique and often complex healthcare needs, an appointment with a PT ought to be arranged. There are several options that the client may have to access physiotherapy for the purpose of chronic disease management. For example, if a PT is available within the primary care setting, such as the FHT, where an RN or MD initially saw them, an appointment with the in-house PT can easily be arranged. However, given that there are fewer than 40 full-time equivalent PT positions that recently opened in Ontario's primary care system, chances are a primary care team may not have a PT member. In such an instance, the client may be connected with a Community Care Access Center (CCAC) to arrange a home-care physiotherapy session, or attend a local private clinic to see a PT. It should be noted that if the client is over 65 years old they are automatically eligible for the episode of care program,[34] which means that a PT in a clinic will receive $312/episode of care (current figures), which is publically funded within private PT clinics (see the Ministry of Health and Long Term Care[35] for a list of participating clinics). Episode of care refers to a discrete group of conditions when specific, time-limited, goal oriented physiotherapy services are appropriate. The episode of care program has no pre-set limits to the number of visits. Instead, the PT and the client identify specific goals for treatment, which then guide the total number of visits. Once these goals are achieved, or no further gains are likely to be achieved with continuing PT service and/or if equivalent gains can be achieved through self-care, or community programs (e.g., falls prevention, exercise classes) the client is discharged.

Despite these various options, primary care teams provide a unique opportunity for clients requiring complex care needs to access publicly-funded healthcare services, delivered by diverse providers within a single location. This practice context enables easy knowledge sharing between clinicians within a multi-disciplinary team and improves the likelihood of achieving better quality, client-centered care.[9] Given the complexity of chronic disease management, a team-based collaboration fits well with the previously discussed Ministry of Health and Long-Term Care Framework for chronic disease prevention and management.[9]

Follow-up Appointment. Once an appointment is made with a PT provider, regular follow-ups need to be scheduled to facilitate client compliance.[9] These follow-ups may be achieved through telephone conversations, e-mails, text-messages, or in-person.

The mode of follow-up is not as important as is consistency, since it has been previously shown that regularly scheduled follow-up telephone calls improved clients' health more than irregular in-person follow-ups.[9] If the client indicates that they have not commenced an exercise program during the follow-up visit, the clinician may proceed by following the 5A's model again until the client receives an appropriate exercise prescription. Figure 4 illustrates the application of the 5A's model during the exercise prescription screening phase.



Legend: CCAC: Community Care Access Center; FHT: family health team; CHC: Chronic Health Center; NPLC: nurse practitioner led clinic; AHAC: Aboriginal Health Advocacy Center.

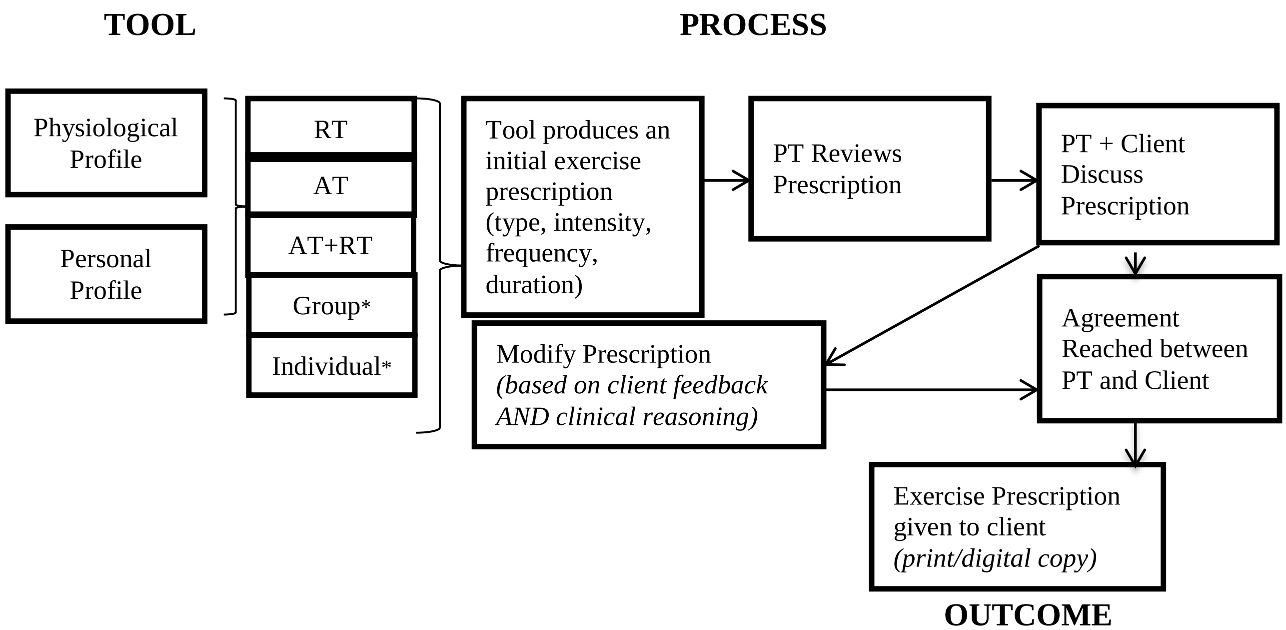
Figure 4: Example of the exercise prescription screening phase.

Phase 2: The exercise prescription tool and process

While the first phase of this chapter proposes a screening approach that may be completed by any initial contact clinicians in primary care, in order to facilitate and/or advocate for exercise, phase 2 introduces a conceptual exercise prescription tool and process. This tool and process is meant to factor in the complexity of chronic diseases and begin addressing *how* an exercise prescription might be tailored to meet the unique needs of individuals often living with more than a single chronic disease. An exercise prescription should include specifics about the type of exercise, frequency, intensity, and duration.[36,37] These specific elements should be included when an exercise prescription is given to the client and it ought to be informed by the individual's unique characteristics. The proposed tool attempts to identify and capture these characteristics in order to show how an exercise prescription can be tailored to meet the individual needs of a person living with chronic disease(s). However, prior to the provision of the final exercise prescription, clinical reasoning and client collaboration is crucial in order to modify the program to suit the unique needs of the client. Thus, PTs' clinical reasoning and the client are central in the process as they ultimately co-create the final exercise prescription.

For the purpose of the proposed tool, the factors that can influence exercise prescription are categorized into the physiological profile and the personal profile. The physiological profile refers to chronic diseases the client may have, while the personal profile includes consideration of individual characteristics that can influence exercise participation, such as personal preferences. Furthermore, social determinants of health such as income, employment, and the built environment also fit within the personal profile, since they may influence one's ability to be active.[38] Consideration should be given to all of these elements for an exercise prescription to be relevant, realistic, and meaningful for an individual and their personal lifestyle context.

Boudreau and colleagues[39] recently found that a computer-tailored, print-based exercise intervention provided to French-Canadians with type 2 diabetes led to greater compliance to exercise than generic activity recommendations. Building on these findings, the proposed exercise prescription tool introduces examples of algorithms that could be computerized in the future to expedite the application of a tailored exercise prescription. Figure 5 shows the exercise prescription process, including components of the electronic tool, clinical reasoning, and client collaboration, all contributing to a tailored exercise prescription as the final outcome.



Legend: PT: physiotherapist; RT: Resistance Training; AT: Aerobic Training; *Personal preference to exercise within a group or as an individual.

Figure 5: Exercise Prescription Process.

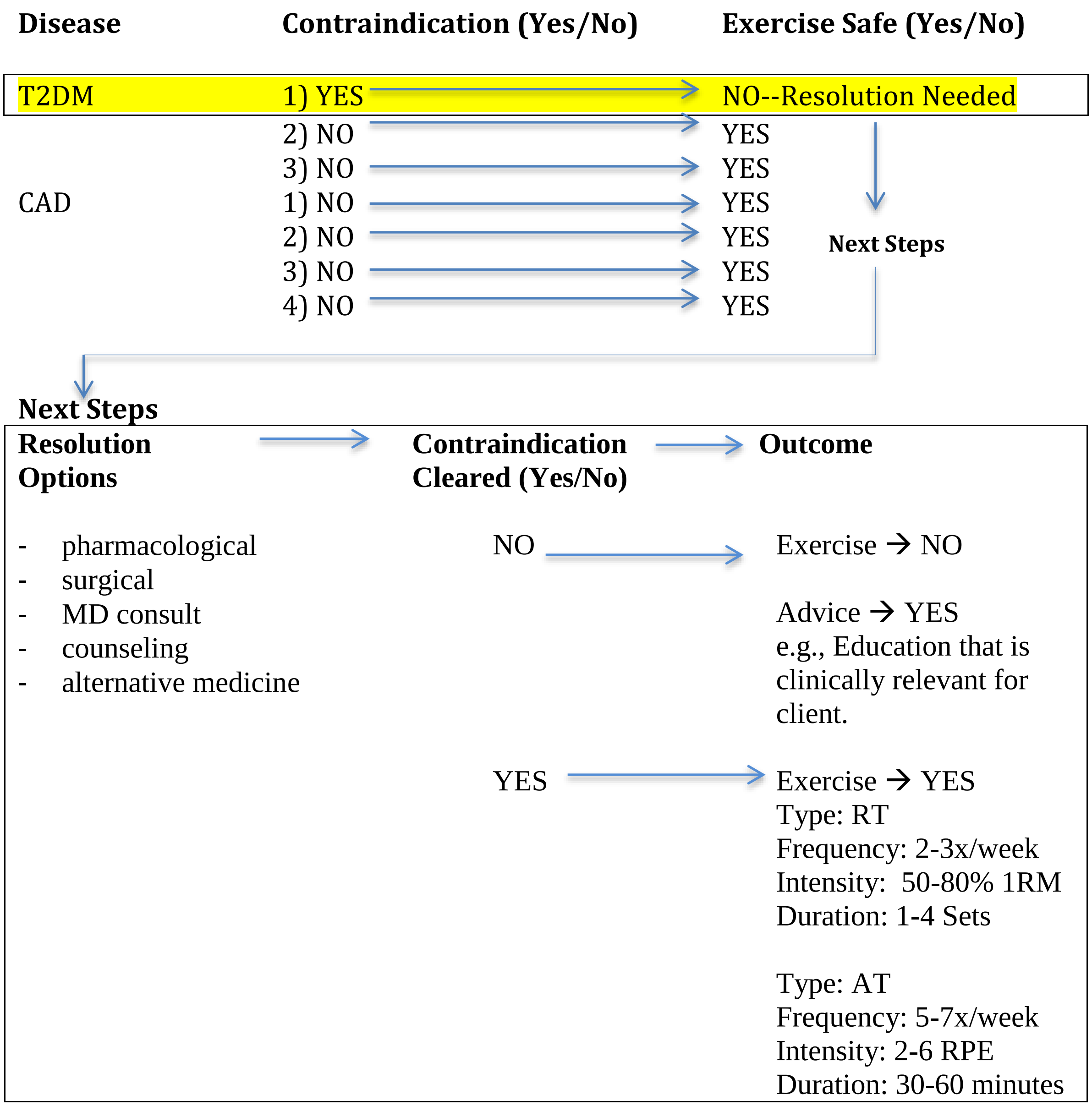
What is meant by the physiological profile? The physiological profile refers to the client's chronic diseases, which will inform the specific contraindications to exercise. Given that there are currently established exercise guidelines for over 49 chronic conditions[15] future efforts might enable extrapolation of key physiological factors from various systems of the body (cardiovascular, neurological, endocrine, etc.,) to inform individualized exercise prescriptions. Extracting key physiological factors from over 49 chronic diseases is outside of the scope of this thesis, but a small-scale example is provided to demonstrate how key factors from established exercise guidelines[15] might be incorporated into a computer-based tool to guide a tailored exercise prescription. The proposed tool's software would expedite the analysis of various contraindications using appropriate algorithms to determine a risk assessment unique to the client's physiological profile. The tool would initially indicate whether it is safe for a person to commence an exercise program. The necessary data to inform the client's physiological profile could be obtained from the electronic medical record (EMR), or a combination of questionnaires and diagnostic test results. Appendix I provides an example of the type of data that might be considered by the tool and an example of the algorithm that would help guide the decision process leading to an exercise prescription or an alternative recommendation.

To help illustrate, a case example is presented, informed by the leading chronic diseases reviewed in chapter 3 of this thesis. If a person with type 2 diabetes mellitus (T2DM), coronary artery disease (CAD), and chronic obstructive pulmonary disease (COPD) was prepared to initiate an exercise program, the physiological profile would need to account for the contraindications to exercise first, before a tailored prescription is developed. Table 11 includes the list of contraindications for each of the three leading chronic diseases presented in chapter 3.

Table 11: Chronic diseases and their respective contraindications

Chronic Disease	**Contraindications**
Type 2 Diabetes Mellitus	Autonomic neuropathy Severe peripheral neuropathy Pre- or proliferative retinopathy
Coronary Artery Disease	Unstable angina Uncontrolled arrhythmia Stenotic/uncompensated valves Hypertrophic obstructive cardiomyopathy
Chronic Obstructive Pulmonary Disease	Severe hypertension Hypoxemia with oxygen below 85% Uncontrolled angina Congestive heart failure

The initial question is whether commencement of an exercise program is safe. Then, informed by current evidence the tool should determine specific exercise (type, duration, intensity, frequency) that is appropriate for the client. The algorithm below illustrates how the tool could sort through this process. In the first instance, one will see that if a contraindication is not cleared that exercise is not a safe outcome and thus an exercise prescription is not provided. However, as a clinician there are alternative outcome options that may still provide beneficial information for the client, such as education (e.g., falls prevention, breathing strategies, safety considerations for activities of daily living, or any other details relevant for the client's unique healthcare needs). On the other hand, if all contraindications are cleared and exercise is determined to be a safe option for the client, the tool would retrieve the evidence from established exercise guideline and provide appropriate, initial exercise prescription options for the client.



Legend: T2DM: type 2 diabetes mellitus; CAD: coronary artery disease; COPD: chronic obstructive pulmonary disease; 1RM: 1 repetition maximum (the maximum amount of resistance that can be lifted once); RPE: rate of perceived exertion (e.g., scale: 0-10 where the a higher number denotes greater activity difficulty as perceived by the individual completing the exercise)

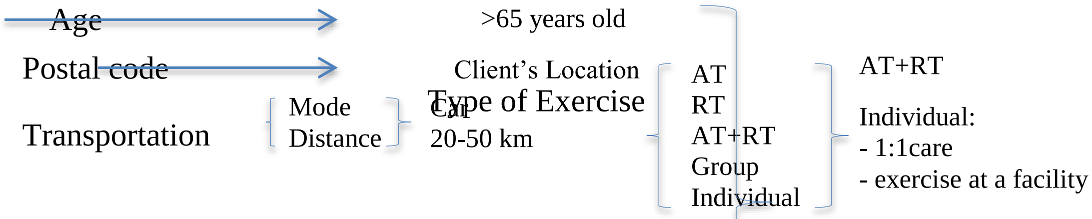
Figure 6: Example of a physiological profile algorithm.

What is meant by the personal profile? The personal profile would be included in the tool to incorporate individual factors that may influence a client's preference for certain activities, and/or indicate resources to facilitate exercise participation. The tool would include client data such as demographics, geographic location, and client's exercise preference, when possible, obtained before the initial assessment. For example, a questionnaire (Appendix J) could be e-mailed or completed over the telephone with the client prior to the first in-person meeting, which could maximize the time the clinician spends interacting with the client during their first visit to begin developing a tailored exercise program that is meaningful to the person. Otherwise, the data could be retrieved and entered into the tool during the first visit. Figure 7 presents an example of a personal profile algorithm, informed by questionnaire in Appendix J, for the purpose of developing a tailored exercise prescription. Additional information can also be added, such as income or the amount of financial investment one can afford towards an exercise intervention. These broader questions are aimed at assessing some of the key social determinants of health, such as income, employment, and the built environment, to help assess the potential access to appropriate services for the client. These factors were taken into account since considering a person's living context can improve likelihood of success with an intervention.[9]

Exercise recommendation based on the personal profile

1) Location(s): list of local Facilities (e.g., private clinics or gyms with 1:1 personal training)
2) Senior (>65): eligible for Episode of care
3) Distance: Treatment facilities located 20-50 km from client's postal code
4) AT+RT (discuss options)

INPUT **PROFILE**



Legend: AT: aerobic training; RT: resistance training; AT+RT: combined aerobic and resistance training.

Figure 7: Example of a personal profile algorithm.

As shown in Figure 5, both the physiological profile and the personal profile are combined in order to inform the initial exercise prescription. The clinician can then spend time discussing the initial exercise prescription with the client and modify it based on clinical reasoning and client feedback, prior to completing a mutually agreed-upon exercise program that is tailored and appropriate for the client.

Implementation Considerations

Previous sections of this chapter introduced the theoretical algorithms that could guide the *how* of exercise prescription within primary care, for the purpose of chronic disease management. However, there are implications that need to be considered before a practical exercise prescription tool can be prepared for implementation. This section will further elaborate on the following implementation considerations: 1) validation of the proposed exercise prescription approach, and 2) potential implementation barriers.

Validation of the proposed exercise prescription approach. At this point the exercise prescription approach is conceptual in nature and before extensive resources are allocated into further development, validation of the proposed approach is necessary. An appropriate technique that could be employed to begin validating the proposed approach is the Delphi technique, primarily developed by the Rand Corporation in the 1950s and Dalkey and Helmer (1963).[40] Previous researchers[41] suggest that the Delphi technique can be used for the following:

"*1) To determine or develop a range of possible program alternatives; 2) To explore or expose underlying assumptions or information leading to different judgments; 3) To seek out information which may generate a consensus on the part of the respondent group; 4) To correlate informed judgments on a topic spanning a wide range of disciplines and; 5) To educate the respondent group as to the diverse and interrelated aspects of the topic*" (p11).

In other words, this technique can be used for consensus building to determine whether the proposed exercise prescription approach is appropriate for the primary care context. Hsu and colleagues[40] provided an in-depth review on how the Delphi process is employed to reach consensus. The reader is directed to this review for extensive details, but a general summary of the process is provided to help illustrate how the validation of the proposed approach can be commenced.

The Delphi process begins with round one, where an open-ended questionnaire is distributed to solicit specific information from relevant participants or a panel of experts. In this instance, it would consist of primary care team members, including MDs, RNs, and PTs, since the proposed exercise prescription approach would directly impact this group of professionals. Upon attaining approval for a Delphi study by an appropriate ethics board, convenience sampling would be completed to connect with primary care teams that employ MDs, RNs, and PTs. There are currently 150 primary care teams in Ontario, and to improve likelihood of the consensus being representative, there should be a primary care team from diverse regions across Ontario, including both rural and municipal teams. After participating teams are secured, the participants would be sent all necessary details and background of the proposed exercise prescription approach along with the first round of questionnaires. The participants would be provided with approximately 2 weeks to review the background information and complete the first round of questionnaires. Although the traditional Delphi technique uses open-ended questionnaires to assist the development of the second round of questions that are more specific based on participant feedback, a modified Delphi process can be used instead where a structured survey is employed based on an extensive literature review of basic information concerning the issue. The modified Delphi process may be appropriate for the purpose of reaching consensus regarding the proposed exercise prescription approach, as long as the participants are provided with the background information and the details of the conceptual model described in this thesis.

Once the initial data from the first round of questions is obtained, the panel of experts would receive a second survey to review the summary of their initial responses and rank the items to determine priorities. For example, participants may rate that having a tool screen through key contraindications to inform their prescription process is more important, than including the screening phase or the 5 A's model. This is the phase where agreements and disagreements amongst participants are identified, thereby initiating the formation of consensus. Following along is the third round where each of the participants is provided with the questionnaire that now includes the items along with ratings, and the participants are asked to revise their judgments, or to elaborate reasons for remaining outside of the consensus achieved in round two. The outcome of round three is to fine-tune the consensus from the second round. Finally, round four of the Delphi process aims to provide participants one last opportunity to modify their judgments before the final consensus is reached.

The Delphi technique would be a valuable first step in the validation of the proposed exercise prescription approach. The primary consensus that would need to be reached regarding the exercise prescription approach includes addressing several key questions. For example:

1) In your expert opinion, would an evidence-informed and systematic approach be useful to facilitate exercise prescription for individuals living with more than one chronic disease(s)?
2) In your expert opinion, would you use the 5 A's model (described in your background information package) to facilitate exercise advocacy?

3) Based on the physiological and personal profile algorithms that you have reviewed, do you think that a tool designed to systematically analyze such data to inform your exercise prescription would be useful?
4) Would you use the proposed exercise prescription tool if it were developed?
5) What, if any, barriers do you think would exist with using the proposed exercise prescription approach?
6) In your expert opinion, should the proposed exercise prescription approach for the purpose of chronic disease management be implemented in primary care?
7) Please share further thoughts that were not addressed directly in the questionnaire?

As shown by the sample of potential questions, a consensus would need to be reached regarding three major themes: 1) usefulness of the proposed exercise prescription approach in primary care; 2) barriers to implementation; and finally, 3) if further steps ought to be taken to further develop the proposed approach. One of the main reasons for starting the validation process with the Delphi technique is due to the relevance of the proposed exercise prescription approach and tool where the Delphi method attempts to address what could/should be done. [40]

If consensus is reached (i.e., 90-100% agreement per item/question amongst participants) that the proposed exercise prescription approach is worth developing further, the next step would include organizing a team of experts to develop an implementation protocol for the proposed exercise screening (5A's) and a preliminary software-based exercise prescription tool that takes into account the physiological and personal profiles described earlier. Once the tool based on initial algorithms proposed in this study is finalized, it could be pilot tested within primary care teams across Ontario and later on across Canada. The purpose of the pilot test would be to further validate the exercise prescription approach by conducting a process evaluation to determine if and how it could be implemented in the primary care context, while an outcome evaluation would follow the process evaluation to help inform the effectiveness of the implemented exercise prescription approach.

Potential implementation barriers. There are several potential barriers that could limit the implementation of the proposed exercise prescription approach, which are subdivided and elaborated further within the following categories: 1) Financial; 2) Access; 3) Time, and; 4) Acceptance of PTs' role in chronic disease management.

Financial. Developing an effective electronic tool to facilitate efficient exercise prescription for individuals with multiple chronic disease(s) can be an expensive endeavor. For instance, Canada Health Infoway invested over $1.2 billion by 2004 towards optimizing the use of electronic health/medical records (EMR).[42] Despite this large investment, data from 2006 Commonwealth Fund International Health Policy Survey of Primary Care physicians showed that only 23% of primary care physicians use EMRs in Canada, compared with 89% in the United Kingdom.[43] Concerns such as cost, privacy, security, and design likely contributed, at least in part, to the low adoption rate of EMRs in Canada's primary care system.[44] That being said, a more recent Ontario survey in 2010[45] showed that there is an increase in the use of EMRs, which suggests that technological tools are becoming more accepted within the primary care context. Increased adoption of health-based technology systems can lead to improved management of individuals with chronic disease, by improving their ability to document, as well as follow-up adverse outcomes, and improve implementation of practice guidelines.[43,46] Thus, the cost of developing an effective, technologically-based tool to assist primary care providers with tailoring exercise prescription for individuals with multiple chronic diseases presents a potential barrier for implementation. Future financial and needs assessments ought to be completed to determine if the proposed approach is a cost-effective and viable solution for the primary care context. In addition to the cost associated with developing a comprehensive exercise prescription approach, consideration ought to be given to Canada's healthcare system and its funding structure, which directly impacts the potential access to necessary care and is further discussed next, as another potential barrier to implementation.

Access. Historically, Canada's publicly funded (Medicare) healthcare system was founded on the philosophy that access to healthcare should be based on need and not one's ability to pay.[47] Canada's Health Act guided the legislation where all medically necessary services are covered by the publicly funded sector. This philosophy of practice enables clinicians or healthcare professionals to deliver care in the best interests of clients without financial compensation influencing their decisions.

At this time, PT services are funded through both public and private sources, with increased privatization presenting a potential barrier to effective implementation of the proposed exercise prescription approach.[7] As mentioned earlier, recent inclusion of Ontario PTs in primary care provides an opportunity to improve access for clients to receive necessary care in one location. However, a primarily population-based approach to care delivery is needed, since fewer than 40 full-time equivalent positions were made available for PTs in primary care. [10] This approach might be effective for some clients, but individuals with more complex healthcare needs will often require one-on-one care to ensure that safe interventions are implemented.

Although PTs may be best-prepared to lead exercise prescription for the purpose of chronic disease management, inadequate publicly accessible options could limit the provision of care to those who need it the most. It has been previously reported that two main reasons that primary care physicians do not refer clients to PTs include increased privatization making PT care too expensive and a long waiting list for publicly funded PT programs.[5] Individuals with chronic musculoskeletal conditions, cardiopulmonary conditions and general debility, such as elderly with chronic disease, were at least three times more likely to receive PT services at publicly funded than privately funded practice settings.[5] This means that the current structure of PT service delivery in the community limits access to necessary care. Home-care programs, such as those offered through Community Care Access Centers or the Community Health Centers, have enabled access for some clients who could potentially benefit from a tailored exercise program, but there is little to no direct interaction and collaboration with multi-disciplinary clinicians in these settings.[5] Such an environment may not be optimal for the implementation of the proposed exercise prescription approach. Thus, inappropriate or limited access to necessary care poses another potential barrier.

With the new addition of PTs into family health teams, the accessibility gap may slowly begin to decrease. However, recognizing the complexity and related need for one-on-one care delivery suggests that a greater number of primary care PTs will eventually be required to effectively implement appropriate, tailored, and comprehensive exercise prescriptions.

Time. Although the proposed exercise prescription approach is meant to be comprehensive and expedite efficiency of exercise prescription through utilization of an electronic tool, time can present a barrier to implementation. Time has often been highlighted as a common barrier to incorporating exercise prescription in primary care.[48] With the proposed exercise prescription approach, MD's and RN's involvement takes on the role of exercise advisors or facilitators. Therefore, time demands, albeit brief and less demanding than the development of a full exercise prescription, could still present a barrier that could limit acceptance and implementation of the proposed approach by all of the primary care providers. On the other hand, the electronic tool aims to expedite exercise prescription for the PTs, but a potentially significant learning curve is likely to be expected, which places a demand on PTs willingness to commit their time to learn how to use the new exercise prescription tool.

Acceptance of PTs role in chronic disease management. Acceptance by the public as well as the healthcare community of PTs role in chronic disease management may present a barrier to implementing the proposed exercise prescription approach. Previous research suggests that even when family health team members like MDs and RNs perceive PT as being important, there is often a lack of understanding on the part of referring MDs and RNs as to what PTs can accomplish.[7] Thus, it may not be as surprising that physicians have been found to underuse rehabilitation services that currently exist, particularly in the care of elderly and those with chronic diseases.[5] In addition to primary care providers' acceptance of PTs for chronic disease management, the public may have limited understanding and acceptance of PTs scope of practice, with limited knowledge of their relevance for chronic disease prevention and management.[23,49] Therefore, primary care providers' and the public's limited understanding of PTs role in chronic disease management present potential barriers to implementing the proposed exercise prescription approach.

Conclusion

The proposed exercise prescription approach may benefit the Canadian population. Recognizing the well-acknowledged benefits of exercise[50-54] (improvement in function, decrease in pain, and reduction of morbidity as well as mortality) and that over half of the population 65 years of age and older have more than one chronic disease,[55] presents a strong case that despite the barriers, efforts towards establishing effective and efficient exercise prescription within primary care is a worthwhile endeavor.

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Chapter 5: Final Discussion

Introduction

Chronic diseases are a growing global epidemic, attributing to the death of over 36 million people per year worldwide.[1] Closer to home, 67% of Canadians who die every year succumb to either cancer, diabetes, cardiovascular, or chronic respiratory diseases.[1] Canadians of all ages are affected by chronic disease and although seniors are living longer they are often burdened by multiple chronic conditions.[1,2] This growing epidemic has contributed to a significant personal and economic burden. For example, 2008 figures showed that the total burden of illness and disease in Canada was $192.8 billion, with direct costs reaching $175.6 billion and indirect costs were at 17.9 billion.[3,4] The contributing cost of only three chronic conditions (cardiovascular, diabetes, and respiratory disease) cost the Canadian healthcare system approximately $18 billion in 2008.[4]

There are numerous factors that contribute to the growing chronic disease burden. Some of these are modifiable risk factors such as tobacco use, excessive alcohol consumption, unhealthy diet, and physical inactivity,[3,5] while broader considerations include, social and economic factors, such as income, environment, and culture.[1,6] Notable recent efforts, such as the Exercise is Medicine initiative[7,8] are attempting to address the burden of chronic disease by calling upon primary care providers to begin prescribing exercise in their daily practice.

Given the extensive burden of chronic diseases and recognizing the potential benefits of exercise, this thesis set out to determine: 1) who is adequately prepared to prescribe safe and effective exercise to those affected by chronic disease(s); 2) what factors need to be considered when prescribing exercise, and finally; 3) how can an exercise prescription be tailored to meet the unique and complex needs of those affected by more than a single disease.

The "Who" of Exercise Prescription

Over the past decade compelling advocacy has been made for physicians[9-14] to play a key role in exercise counseling and prescription, while others[15,16] have suggested nurses incorporate exercise prescription as part of their health promotion mandate.

However, previous researchers[17,18] found that medical schools from the United States and United Kingdom provide limited exercise education within their curriculum, with minimal opportunity to develop a specific exercise prescription. This thesis further builds upon this literature as it demonstrated the trend that medical and nursing programs in Canada also do not provide extensive (if any) exercise education as a mandatory component of their current curricula. However, a major finding that did emerge is that although medical (MD), nursing (RN), and physiotherapy (PT) students are taught general concepts about the benefits of exercise and could thus be exercise advisors or facilitators, only PTs know how to prescribe, implement, and modify exercise with all individuals, including those living with chronic disease(s). This means that significant curricula changes would need to be made in order to educate MD and RN students how to prescribe an appropriate exercise program, while PTs are already well prepared to take on this role by the time they complete their professional program.

Although one strategy is to implement medical[17-19] and nursing[20] curricula changes that incorporate exercise as a mandatory component of their students' education, resources may be better allocated to rely on primary care providers who already have extensive exercise prescription knowledge—physiotherapists. Even if curricula changes are implemented within medical and nursing programs their clinical practice context is more appropriate for exercise counseling or advising, rather than providing an appropriate, tailored exercise prescription to meet the needs of clients.[14,20] Physiotherapists on the other hand work within environments where exercise prescription is a fundamental component of their daily practice.[21] Now that PTs are being included within family health teams, there is a unique opportunity for them to make a meaningful contribution by effectively implementing exercise prescription in primary care.

Note however that while PTs may be best prepared to effectively implement exercise prescription in primary care, a challenge persists since there are limited opportunities for PTs to work in this clinical setting.[22,23] Although PTs employed in primary care often develop group exercise programs for various populations, one-on-one care that may be necessary to tailor an exercise program for someone living with multiple chronic diseases still presents a potentially significant challenge. Currently, PTs working in Ontario primary care settings are sometimes expected to oversee the care of 500 to 7000 clients.[23] With less than 40 full-time equivalent PT primary care positions made available in Ontario, it can be reasoned that limited access to PT services will persist in this clinical practice context. Therefore, greater investment in primary care to increase the number of PTs that are made available to the public is worthwhile.

It has also been reported that the elderly with chronic disease(s) mainly access publicly funded PT services[24] and that MDs rarely refer clients for PT interventions due to the high cost associated with increasing sector of private PT care delivery.[24,25] This barrier means that those who most often need and could benefit from PT services (i.e., elderly with chronic diseases) have limited access. In order to implement effective exercise prescription by the best prepared primary care providers—physiotherapists—and begin addressing the long called improvement in chronic disease prevention and management within primary care,[6,26] there needs to be ongoing advocacy to improve access to publically funded PT services. This advocacy might benefit from capacity building to improve public and primary healthcare professionals understanding of PTs scope of practice. Given that primary care MDs and RNs have previously indicated limited awareness of PTs scope and competencies, a number of individuals with chronic diseases who could benefit from PT are never referred for appropriate services.[27] Thus, those in need would lose out on potentially beneficial PT interventions.

The "What" of Exercise Prescription

This thesis also highlighted *what* factors should be monitored to ensure safety with exercise in individuals with multiple chronic diseases. The systematic literature review from this thesis showed that there were key overlapping physiological markers and subjective markers when a comparison of exercise recommendations is completed for three common chronic diseases: coronary artery disease (cardiovascular system), type 2 diabetes mellitus (endocrine system), and chronic obstructive pulmonary disease (respiratory system). The concept behind this study was to begin looking at exercise prescription from a multi-system approach versus the currently dominant exercise guidelines, which take into account a single disease.[28-32]

The most common overlapping markers that emerged from this thesis include: systolic blood pressure, diastolic blood pressure, rate of perceived exertion, and heart rate. There are also overlapping markers and contraindications to exercise from multiple chronic diseases, alluding to a possibly innovative way for clinicians to prescribe and monitor limits of safe exercise for individuals with more than one chronic disease. Although researchers have provided examples of exercise prescription frameworks[12,33] this is the first attempt to integrate several chronic diseases to guide exercise-prescription decision-making. An algorithm was developed during this thesis to help guide clinicians when assessing individuals for disease-specific contraindications to exercise. For instance, clinicians are guided on how to assess common physiological and subjective markers such as blood pressure, heart rate, and rate of perceived exertion, and then prescribe an appropriate exercise plan.

Integration of the unique and overlapping markers that emerged from the systematic review suggest that it may be possible to tailor exercise programs to individuals with multiple chronic diseases, by taking into account key markers from each system. Future research considerations discussed later in this chapter elaborate more details about how this multi-system approach to exercise prescription can be further developed.

The "How" of Exercise Prescription

A conceptual approach on *how* exercise prescription may be operationalized for individuals with chronic disease(s) within primary care emerged from this thesis. Although initiatives and exercise guidelines emphasize the importance of a tailored exercise prescription, there is little guidance on how this can be accomplished within primary care when working with individuals who have multiple chronic diseases. From the proposed exercise prescription approach in this thesis two main components emerged: 1) the exercise prescription screening and 2) the exercise prescription tool.

A major takeaway is that physicians and nurses, who are often the first point of contact, are well positioned within primary care to act as advisors or facilitators for exercise prescription, while physiotherapists ought to prescribe a tailored exercise program for the purpose of chronic disease management. Previous researchers[34] have also suggested that reliance on allied health professionals, such as PTs for appropriate interventions like exercise prescription, could decrease wait times to see a specialist and lead to improved functional outcomes (e.g., improved walking tolerance).

The 5 A's model, comprised of Ask, Advise, Assess, Assist, and Arrange elements is a tool that primary care providers such as MDs or RNs can use to advise clients about the benefits of exercise, as well as encourage or facilitate exercise participation. Researchers from Sweden have used a similar approach with the 5A's model to assist the public in navigating their healthcare system and to promote exercise prescription.[35] Thus, further research may show that it is possible to effectively implement the 5A's model for exercise prescription within the Canadian context.

Another point of discussion presented in this thesis is that a future electronic tool could be developed to expedite the screening of contraindications to exercise, while also incorporating social determinants of health when tailoring an exercise prescription for individuals affected by multiple chronic diseases. Although past guidelines have referred individuals to speak with their healthcare professionals for a tailored and appropriate exercise prescription, limited objective and systematic protocols are available for clinicians when designing personalized exercise prescriptions for those with multiple chronic disease(s).

It has been previously shown that making a program meaningful to the individual, by taking into account their personal life context and also providing a printed exercise prescription sheet, is more effective at achieving exercise compliance when compared with solely providing advice to be active.[36] Thus, the exercise prescription approach proposed in this thesis begins to address *how* broad exercise guidelines could be used in order to personalize an exercise prescription to meet the unique needs of those affected by multiple chronic diseases.

Limitations and Future Research Directions

Although care was taken to complete a comprehensive thesis report, there are several notable limitations that are discussed. First, the survey that was administered across Canada did not assess every professional program, but it solely focused on MDs, RNs, and PTs, limiting the generalizability of findings. Further caution with interpreting and generalizing findings ought to be taken regarding Canadian medical school exercise curricula due to the low response rate. The low response rate may be attributed to the timing (summer term) of survey distribution, as well as a potentially low priority of this exercise topic to medical schools. Also, the survey may have had greater buy-in from MD and RN programs if a fellow colleague from their respective profession administered the questionnaire, rather than a graduate student from a combined PT/PhD program.

Second, the survey that was administered only takes into account the viewpoint of a single person (i.e., the program director) and could thus be at risk of bias to that participant. Third, the systematic review was limited by the use of the term “guideline”, as this decreased the number of possible randomized controlled trials that were found in the initial search results. Omitting this term in future database searches may produce a greater number of studies relevant for review. In addition, higher levels of evidence may be attained if a meta-analysis or a systematic review of previous systematic reviews was completed to enable collection and analysis of a greater breadth of data. These are all relevant and appropriate considerations for future research efforts in this area of study.

There are additional directions to be considered with future research efforts. First, a survey of PT students' perceptions of exercise prescription curricula offered during their education would provide important insight on how prepared they feel to prescribe exercise to individuals with chronic disease(s). On a related note, an evaluation could be completed to determine the confidence of PTs in primary care regarding development of exercise prescription interventions for individuals living with multiple chronic diseases. In addition to the three professional programs evaluated in this thesis, other primary care and/or alternative healthcare providers' exercise curricula may be assessed to determine if there are additional clinicians who could contribute to the exercise prescription movement for those living with multiple chronic diseases. Kinesiologists' potential role in exercise prescription within primary care is especially worth studying in the future given their recently increasing autonomy as regulated professionals.

Future research may build on the systems-based exercise prescription concept introduced in chapter 3 of this thesis. Specifically, the systematic review illustrated the extensive complexity associated with extrapolating key physiological markers in order to tailor an exercise program for individuals with multiple chronic diseases. Due to this complexity, attempts at developing systematic guidelines for those affected by multiple chronic diseases has presented a considerable challenge. Limited time and funding restricted the ability to determine if key physiological markers could be identified and extracted from each of the 11 systems of the human body in order to determine a person's physiological profile, regardless of the specific diseases present. Current exercise guidelines[32,37] are designed with considerations of the generally healthy populations who fall within specific age ranges, or for those affected by a single disease. Within current exercise guidelines,[32] extensive recommendations are provided regarding contraindications to exercise when a specific disease is present, but little systematic guidance exists to assist clinicians in tailoring exercises for those with multiple chronic diseases.

To further build upon the review completed in this thesis, future consideration should be given into looking at each system of the body to attempt extracting key markers associated with a high-risk event (i.e., severe injury or death) if the marker falls outside of its safe range. For example glucose would be considered a key marker associated with the endocrine system and if the levels are too low a person is at risk of hypoglycemia and possible death unless an appropriate intervention is provided. With this concept in mind, if major or key markers per system are extracted and classified per system, then tailoring an exercise prescription could be based on screening for these markers. As long as the key markers are in their safety zones then the person may be cleared for exercise and monitored over time, regardless of what specific disease(s) they have.

Classification of each key marker affected with exercise into respective systems of the body may be possible in the future. For example, heart rate is a marker that is monitored in those with coronary artery disease, chronic obstructive pulmonary disease, and diabetes, but it would be classified into the cardiovascular system. Similarly to heart rate, blood pressure would also be classified under the cardiovascular system, while markers such as VO_2 max and arterial oxygen saturation (SpO2) would be grouped under the respiratory system classification. Extensive research and screening of the most recent exercise guidelines could be done in the future to extract key factors across all major chronic diseases and then determine if these markers could be grouped within the body's major systems. The purpose of attempting such an approach would be to enable addressing *how* exercises could be tailored for those with multiple chronic diseases regardless of the disease(s) present. This may be possible, since the key markers from the body's systems would be screened for safety, rather than checking each disease and reading separate contraindications associated with a single condition.

Finally, if the exercise prescription electronic tool is developed in the future it could assist clinicians by expediting the exercise prescription process by quickly screening exercise contraindications, while also taking into account social determinants of health to make the prescription relevant to the individual's life context. However, future research ought to be done to validate the exercise prescription approach and tool introduced in chapter 4 of this thesis, before extensive resources are allocated into further tool development. Completing a Delphi study to determine whether the approach should be developed further would be the first step, followed by a process evaluation of a pilot study where the developed tool is implemented within primary care. An outcome evaluation could then be completed to determine the effectiveness of the exercise prescription approach and electronic tool. Ultimately too, the potential financial benefits to the current healthcare system need to be assessed.

Conclusion

Key takeaways from this thesis are that although it has been previously advised to alter medical and nursing curricula to incorporate exercise education this restructuring approach would be difficult and unlikely represents the most efficient use of resources.

This thesis provides evidence that Canada's primary care system already has physiotherapists who are well prepared to lead the exercise prescription movement for the purpose of chronic disease management. However, advocacy and funding support for PTs to be better integrated with publicly funded primary care settings is needed to enable people with chronic disease(s) to reap the benefits of tailored exercise prescriptions.

Further efforts are also warranted to establish a systematic way to effectively guide exercise prescription for individuals affected by multiple chronic diseases. Although experiential clinical reasoning and collaboration with clients will continue to play an important role during the development of an exercise prescription, there ought to be more evidence-based, objective protocols that can more specifically guide decision-making when working with individuals with multiple chronic diseases, rather than having to interpret and collate separate guidelines for each comorbid disease for every new client. Therefore, a systems-based approach may complement the currently dominant exercise guidelines that were developed to assist clinicians to prescribe an exercise program for a person with a single chronic disease. Ultimately, this systems-based approach poses an innovative way to begin addressing exercise prescription decision-making for individuals with multiple chronic diseases.

In conclusion, due to the extensive personal and economic burden of chronic disease, incorporating precise exercise prescription from physiotherapy experts within primary care is a worthwhile endeavor. The barriers such as cost, time demands, limited access to PTs in primary care, and poor acceptance of physiotherapists' role in chronic disease management need to be addressed by effective, determined advocacy from the profession.

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Appendix A: Ethics Approval

Western Research

Research Ethics

Use of Human Participants - Initial Ethics Approval Notice

Principal Investigator: Dr. Anthony Vandervoort
File Number:105171
Review Level: Delegated
Protocol Title: Exercise prescription curriculum in Canadian medical, nursing, and physiotherapy programs
Department & Institution: Health Sciences\Physical Therapy,Western University
Sponsor:
Ethics Approval Date: May 06, 2014 **Expiry Date:**August 31, 2015
Documents Reviewed & Approved & Documents Received for Information:

Document Name	Comments	Version Date
Other		2014/03/20
Instruments	Attached is a word version of the survey that illustrates the content of the survey. However, the actual survey will accessed through the following link: http://freeonlinesurveys.com/app/rendersurvey.asp?sid=ml9dzmz0xlw0xxd417697&refer	2014/03/20
Revised Letter of Information & Consent	Revised LOI for 105171 Vandervoort and Hovanec Clean Copy - PDF	
Revised Western University Protocol	Revised Protocol 195171 Vandervoort and Hovanec - Clean Copy in PDF version of April 29-214	

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced revision(s) or amendment(s) on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the University of Western Ontario Updated Approval Request Form.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

The Chair of the HSREB is Dr. Joseph Gilbert. The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

Ethics Officer to Contact for Further Information

___ Erika Basile (ebasile@uwo.ca)	___ Grace Kelly (grace.kelly@uwo.ca)	___ Mina Mekhail (mmekhail@uwo.ca)	___ Vikki Tran (vikki.tran@uwo.ca)

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Appendix B: Response Frequency

Question Director	Response (frequency)					
	Strongly Agree (%)	Agree (%)	Do Not Know (%)	Disagree (%)	Strongly Disagree (%)	No Answer (%)
Q1						
PT	10	0	0	20	70	0
RN	0	10	0	60	30	0
MD	0	25	0	50	25	0
Q2						
PT	100	0	0	0	0	0
RN	20	10	30	40	0	0
MD	0	50	0	0	50	0
Q3						
PT	100	0	0	0	0	0
RN	0	10	0	80	10	0
MD	0	0	0	75	25	0
Q4						
PT	100	0	0	0	0	0
RN	10	0	0	60	30	0
MD	0	0	0	50	50	0
Q5						
PT	80	20	0	0	0	0
RN	10	10	10	60	10	0
MD	0	0	0	50	50	0
Q6						
PT	100	0	0	0	0	0
RN	0	50	10	30	10	0
MD	0	0	0	50	50	0
Q7						
PT	100	0	0	0	0	0
RN	0	50	0	50	0	0
MD	25	25	0	25	25	0
Q8						
PT	100	0	0	0	0	0
RN	10	50	10	20	10	0
MD	25	25	0	0	25	25
Q10						
PT	90	0	0	0	0	10
RN	10	70	0	20	0	0
MD	0	75	0	0	25	0
Q11						
PT	90	0	0	0	0	10
RN	0	60	10	30	0	0
MD	0	75	0	0	25	0
Q13						
PT	60	0	0	10	0	30
RN	20	0	0	60	20	0
MD	25	50	0	0	25	0
Q14						
PT	0	70	0	0	0	30

RN	10	10	10	50	10	10
MD	25	50	0	25	0	0
Q15						
PT	60	0	0	0	0	40
RN	10	10	40	30	10	0
MD	25	25	0	25	25	0

* Q=question, thus Q1 represents Question 1 from the survey, etc.; PT=Physiotherapy Program Directors; RN=Nursing Program Directors; MD=Medical Program Directors.

Appendix C: t-test Tables

Group Statistics					
	Profession	N	Mean	Std. Deviation	Std. Error Mean
Q1	PT	10	4.4	1.265	0.4
	RN	10	4.1	0.876	0.277
Q2	PT	10	1	0	0
	RN	10	2.9	1.197	0.379
Q3	PT	10	1	0	0
	RN	10	3.9	0.738	0.233
Q4	PT	10	1	0	0
	RN	10	4	1.155	0.365
Q5	PT	10	1.2	0.422	0.133
	RN	10	3.5	1.179	0.373
Q6	PT	10	1	0	0
	RN	10	3	1.155	0.365
Q7	PT	10	1	0	0
	RN	10	3	1.054	0.333
Q8	PT	10	1	0	0
	RN	10	2.7	1.252	0.396
Q10	PT	9	1	0	0
	RN	10	2.3	0.949	0.3
Q11	PT	9	1	0	0
	RN	10	2.7	0.949	0.3
Q13	PT	7	1.43	1.134	0.429
	RN	10	3.6	1.43	0.452
Q14	PT	7	2	0	0
	RN	9	3.44	1.236	0.412
Q15	PT	6	1	0	0
	RN	10	3.2	1.135	0.359

* Q=question (Example: Q1 represents Question 1 from the survey); PT=Physiotherapy Program Directors; RN=Nursing Program Directors.

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Q1	Equal variances assumed	0.72	0.409	0.617	18	0.545	0.3	0.486	-0.722	1.322
	Equal variances not assumed			0.617	16.014	0.546	0.3	0.486	-0.731	1.331
Q2	Equal variances assumed	19.6	0	-5.019	18	0	-1.9	0.379	-2.695	-1.105
	Equal variances not assumed			-5.019	9	0.001	-1.9	0.379	-2.756	-1.044
Q3	Equal variances assumed	3.76	0.068	-12.429	18	0	-2.9	0.233	-3.39	-2.41
	Equal variances not assumed			-12.429	9	0	-2.9	0.233	-3.428	-2.372
Q4	Equal variances assumed	3.86	0.065	-8.216	18	0	-3	0.365	-3.767	-2.233
	Equal variances not assumed			-8.216	9	0	-3	0.365	-3.826	-2.174
Q5	Equal variances assumed	6.08	0.024	-5.811	18	0	-2.3	0.396	-3.132	-1.468
	Equal variances not assumed			-5.811	11.267	0	-2.3	0.396	-3.169	-1.431
Q6	Equal variances assumed	45	0	-5.477	18	0	-2	0.365	-2.767	-1.233
	Equal variances not assumed			-5.477	9	0	-2	0.365	-2.826	-1.174
Q7	Equal variances assumed	.	.	-6	18	0	-2	0.333	-2.7	-1.3
	Equal variances not assumed			-6	9	0	-2	0.333	-2.754	-1.246
Q8	Equal variances assumed	29.6	0	-4.295	18	0	-1.7	0.396	-2.532	-0.868
	Equal variances not assumed			-4.295	9	0.002	-1.7	0.396	-2.595	-0.805
Q 10	Equal variances assumed	10.7	0.004	-4.099	17	0.001	-1.3	0.317	-1.969	-0.631
	Equal variances not assumed			-4.333	9	0.002	-1.3	0.3	-1.979	-0.621
Q 11	Equal variances assumed	54.4	0	-5.36	17	0	-1.7	0.317	-2.369	-1.031
	Equal variances not assumed			-5.667	9	0	-1.7	0.3	-2.379	-1.021
Q 13	Equal variances assumed	0.5	0.49	-3.339	15	0.004	-2.171	0.65	-3.557	-0.785
	Equal variances not assumed			-3.485	14.672	0.003	-2.171	0.623	-3.502	-0.841
Q 14	Equal variances assumed	13.2	0.003	-3.068	14	0.008	-1.444	0.471	-2.454	-0.435
	Equal variances not assumed			-3.506	8	0.008	-1.444	0.412	-2.395	-0.494
Q	Equal variances	8.15	0.013	-4.68	14	0	-2.2	0.47	-3.208	-1.192

15	assumed									
	Equal variances not assumed			-6.128	9	0	-2.2	0.359	-3.012	-1.388

Appendix D: Sample search history for COPD from Scopus database

18	((TITLE-ABS-KEY(copd) AND PUBYEAR > 2002 AND PUBYEAR < 2014) OR (TITLE-ABS-KEY("chronic obstructive pulmonary disease") AND PUBYEAR > 2002 AND PUBYEAR < 2014)) AND ((TITLE-ABS-KEY(risk) AND PUBYEAR > 2002 AND PUBYEAR < 2014) OR (TITLE-ABS-KEY(adverse) AND PUBYEAR > 2002 AND PUBYEAR < 2014) OR (TITLE-ABS-KEY(contraindication) AND PUBYEAR > 2002 AND PUBYEAR < 2014)) AND ((TITLE-ABS-KEY(treatment) AND PUBYEAR > 2002 AND PUBYEAR < 2014) OR (TITLE-ABS-KEY(testing) AND PUBYEAR > 2002 AND PUBYEAR < 2014) OR (TITLE-ABS-KEY(training) AND PUBYEAR > 2002 AND PUBYEAR < 2014)) AND ((TITLE-ABS-KEY("physical activity") AND PUBYEAR > 2002 AND PUBYEAR < 2014) OR (TITLE-ABS-KEY(exercise) AND PUBYEAR > 2002 AND PUBYEAR < 2014)) AND ((TITLE-ABS-KEY(guideline) AND PUBYEAR > 2002 AND PUBYEAR < 2014) OR (TITLE-ABS-KEY(recommendation) AND PUBYEAR > 2002 AND PUBYEAR < 2014))	99 document results
17	(TITLE-ABS-KEY(guideline) AND PUBYEAR > 2002 AND PUBYEAR < 2014) OR (TITLE-ABS-KEY(recommendation) AND PUBYEAR > 2002 AND PUBYEAR < 2014)	484,953 document results
16	(TITLE-ABS-KEY("physical activity") AND PUBYEAR > 2002 AND PUBYEAR < 2014) OR (TITLE-ABS-KEY(exercise) AND PUBYEAR > 2002 AND PUBYEAR < 2014)	253,439 document results
15	(TITLE-ABS-KEY(treatment) AND PUBYEAR > 2002 AND PUBYEAR < 2014) OR (TITLE-ABS-KEY(testing) AND PUBYEAR > 2002 AND PUBYEAR < 2014) OR (TITLE-ABS-KEY(training) AND PUBYEAR > 2002 AND PUBYEAR < 2014)	3,697,413 document results
14	(TITLE-ABS-KEY(risk) AND PUBYEAR > 2002 AND PUBYEAR < 2014) OR (TITLE-ABS-KEY(adverse) AND PUBYEAR > 2002 AND PUBYEAR < 2014) OR (TITLE-ABS-KEY(contraindication) AND PUBYEAR > 2002 AND PUBYEAR < 2014)	1,801,071 document results
13	(TITLE-ABS-KEY(copd) AND PUBYEAR > 2002 AND PUBYEAR < 2014) or (TITLE-ABS-KEY("chronic obstructive pulmonary disease") AND PUBYEAR > 2002 AND PUBYEAR < 2014)	30,642 document results
12	TITLE-ABS-KEY(recommendation) AND PUBYEAR > 2002 AND PUBYEAR < 2014	188,491 document results
11	TITLE-ABS-KEY(guideline) AND PUBYEAR > 2002 AND PUBYEAR < 2014	333,157 document results
10	TITLE-ABS-KEY(exercise) AND PUBYEAR > 2002 AND PUBYEAR < 2014	205,900 document results
9	TITLE-ABS-KEY("physical activity") AND PUBYEAR > 2002 AND PUBYEAR < 2014	77,061 document results
8	TITLE-ABS-KEY(training) AND PUBYEAR > 2002 AND PUBYEAR < 2014	363,628 document results
7	TITLE-ABS-KEY(testing) AND PUBYEAR > 2002 AND PUBYEAR < 2014	685,411 document results
6	TITLE-ABS-KEY(treatment) AND PUBYEAR > 2002 AND PUBYEAR < 2014	2,799,201 document results
5	TITLE-ABS-KEY(contraindication) AND PUBYEAR > 2002 AND PUBYEAR < 2014	36,304 document results
4	TITLE-ABS-KEY(adverse) AND PUBYEAR > 2002 AND PUBYEAR < 2014	250,697 document results
3	TITLE-ABS-KEY(risk) AND PUBYEAR > 2002 AND PUBYEAR < 2014	1,608,856 document results
2	TITLE-ABS-KEY("chronic obstructive pulmonary disease") AND PUBYEAR > 2002 AND PUBYEAR < 2014	22,681 document results
1	TITLE-ABS-KEY(copd) AND PUBYEAR > 2002 AND PUBYEAR < 2014	22,955 document results

Appendix E: COPD Data Extraction

Author	Publication Year	Article Title	Level of Evidence	Activity Type	Frequency	Intensity	Duration	SpO_2 %	HR bpm	Respiratory Rate breaths/min	SBP mm Hg	DBP mmHg	RPE
Bradley, J, et al.,[47]	2009	Short-term ambulaotry oxygen for COPD (Review)	Highest level of evidence since Meta-Analysis; Potential publication bias	AT (e.g. treadmill, cycle ergometry, 6MWT, step test, incremental walk test)				90%	131-142		195-210	93-101	
Corbridge, S, et al.,[32]	2012	An Evidence-Based Approach to COPD: Part 1		AT (Bicycle Ergometry and treadmill walking)		60-80% of maximal symptoms	20 mins						
Costi, S, et al.,[37]	2009	Effects of unsupported upper extremity exercise training in patients with COPD: A randomized clinical trial (RCT)	The patients and PTs were not blinded.	RT (UE strengthening-Shoulder Abduction, Deltoid lift in the scapular plane, Behind head tricep press, Bicep curls at 90 degrees shoulder abduction, Bicep Curls		3 sets of 10 reps progressing to 12 reps then 15 reps as long it was accomplished with a Borg < 3; weight was increased by 500g once at 15 reps; 50% X1 RM	15 sessions over 3 weeks	90.6 - 92.5%	79.7 - 93.6	20.9 - 21.9			Dyspnea Borg: 1.72 - 3.85; Fatigue Borg: 1.24 - 1.98
Eves, ND, et al.,[19]	2011	Evidence-based	Highest level of	AT, Internal Training, RT	3x/wk (AT);	60-80% max	Intervals of 30 -180	>85%					4-6

		risk assessment and recommendations for physical activity clearance: respiratory disease	evidence since Systematic Review		2-3x/wk (RT)	workload (AT); 80-100% max workload (IT); 50-80% 1RM (RT)	seconds with either complete rest or 30-40% workload max after interval; 1-4 sets of 6-12 reps (RT)						
Gupta, D, et al.,[46]	2013	Guidelines for diagnosis and management of chronic obstructive pulmonary disease: Joint ICS/NCCP (I) recommendations	Highest level of evidence since Systematic Review	AT; RT	15-45 mins, daily to 1x/wk	50% max to maximum tolerable	4-12 weeks with greater benefit based on longer stay.						
Lacasse, Y, et al.,[33]	2006	Pulmonary rehabilitation for chronic obstructive pulmonary disease	Highest level of evidence since Systematic Review	AT (Pulmonary rehab: incremental cycle ergometer)	At least 4x/wk	Maximal exercise capacity 7-34 watts							3.3-4.09/10
Nonoyam, M, et al.,[34]	2007	Oxygen therapy	Highest level of	AT (cycle ergometry	2-3 session	75-80% of peak work	2-15 mins sessions;	92-95%	125-130	30-34	187-197	87-94	

		during exercise training in chronic obstructive pulmonary disease	evidence since Systematic Review; Lack of homogeneity between the articles reviewed. The sample size in all studies reviewed were small which may underpower the overall effects.	with oxygen)	s/wk	rate, 40-60 watts	> 3 wk of training						
Panos, RJ	2009	Exertional desaturation in patients with chronic obstructive pulmonary disease		AT (6MWT, treadmill and overground walking)									
Sharma, BB, et al.,[20]	2011	Pulmonary rehabilitation: An overview		AT (Bicycle Ergometery and treadmill walking)	2-3 sessions/wk	symptom limited, with goal of 80% max workload	30-60 mins for 4-12 weeks						
Zainuldin, R, et al.,[48]	2011	Optimal intensity and type of leg exercise	Highest level of evidence since Systematic	AT & IT (Cycling, Treadmill and ground walking)		high versus low	continuous (no breaks) vs. IT (1-3 min		131-134				7.2 - 7.9

		training for people with chronic obstructive pulmonary disease	Review				breaks)						

Appendix F: CAD Data Extraction

Author:	Publication Year	Article Title	Level of Evidence	Activity Type	Frequency	Intensity	Duration	HR beats/min	SBP mmHg	DBP mmHg	Blood Glucose mmol/L	RPE
Bjarnason-Wehrens, B et al.,[21]	2004	Recommendations for resistance exercise in cardiac rehabilitation. Recommendations of the German Federation for Cardiovascular Prevention and Rehabilitation		RT	2-3x/wk for 6 weeks	30-60% MVC	1-2 sets 5-15 reps		Contraindication >160	contraindication>100		monitor for angina level
Briffa, TG et al.,[9]	2006	Physical activity for people with cardiovascular disease: recommendations of the National Heart Foundation of Australia	Most studies that were assessed for the paper predate the recent interventional and pharmacological advances. The studies mostly involve	AT	most-all days/wk	moderate	30+min /day		contraindication<90 or >180	contrindication <60 or >110	cotraindication <6 or >15	

			men.									
Cornish, AK, et al.,[31]	2011	Interval training for patients with coronary artery disease: A systematic review	Highest level of evidence since Systematic Review; All trials reviewed had methodological flaws such as: no stat mentioned of intention to treat, inadequate reporting of patient comorbidities, insufficient reporting about safety and intervention adherence and limited stats comparing adverse events between groups. Cautionable external validity	AT	2-5x/wk	70% VO2 (low) - 95%VO2 (high)	30-60 min					

			because of convenience sampling.									
deJon, AT, et al.,[36]	2006	Hemostatic responses to resistance training in patients with coronary artery disease (RCT)	A control group was not used in the study therefore limiting the conclusions that can be drawn	RT		12-14 RPE	8 exercises, 1 set, 10 reps	monitor	monitor	monitor		12-14
Lai, S et al., [49]	2004	Treadmill scores in elderly men (RCT)	Study is only generalizable to elderly men. Selection bias.	AT								Stop if >17
Pavy, B et al.,[11]	2010	French Society of Cardiology guidelines for cardiac rehabilitation in adults		AT	3-6x/wk	12-14 RPE	30-60 min	10 bpm below angina threshold	<160			12-14
Perez-Terzic, CM, et al.,[12]	2012	Exercise in cardiovascular diseases		AT/RT	AT=5-7x/wk RT=2-3x/wk	AT=60-70%VO$_2$ RT=30-60%MVC	AT= 20-60 min RT=1-3 sets, 8-12 reps	want 10bpm below angina level				monitor
Vanhees, L, et al.,[14]	2012	Importance of characteristi	RPE doesn't completely	AT/RT	AT= 3-5x/wk, start at	AT=80-90% O$_2$	AT=30-60 min					

		cs and modalities of physical activity and exercise in the management of cardiovascular health in individuals with cardiovascular disease (Part III)	correlate with myocardial function. RPE can be influenced by psychological factors such as: group dynamics, depression, motivation and experience with exercise.		40% HR reserve and increase to 60%; RT=2-3x/wk	uptake, RT= 30-70% 1RM								

Appendix G: Diabetes Data Extraction

Author:	Publication Year	Article Title	Level of Evidence	Activity Type	Frequency	Intensity	Duration	HR beats/min	SBP mmHg	DBP mmHg	Blood Glucose mg/dl	METS	HbA1C	RPE
Araiza, P. et al[23]	2006	Efficacy of a pedometer-based physical activity program on parameters of diabetes control in type 2 diabetes mellitus (RCT)	5/10 PEDro score	AT (walking)	Everyday		10,000 steps per day using a pedometer							
Balducci, S, et al.,[38]	2012	Effect of High- versus Low-Intensity Supervised Aerobic and Resistance Training on Modifiable Cardiovascular Risk Factors in Type 2 Diabetes; The Italian	5/10 PEDro score	AT; RT		Low: 55% max VO_2 (AT); 60% 1RM (RT). Moderate: 70% max VO_2 (AT); 60% 1RM (RT)							improved, higher intensity better	

		Diabetes and Exercise Study (IDES) (RCT)												
Colberg, S. et al.,[6]	2010	Exercise and Type 2 Diabetes (SR)	Highest level of evidence since Systematic Review	AT; RT	3x/wk with no more than 2 consecutive days off (AT); 2x/wk on non consecutive days (RT)	Low: 40-60% max VO_2 or High: >60% max VO_2 (AT); Mod: 50% 1RM or Vigorous: 75-80% 1RM	Minimum of 150 min /wk in bouts of 10 min or longer (AT)				>100 - <300 mg/dl			
Hayes, C. et al[24]	2008	Role of Physical Activity in Diabetes Management and Prevention (Review)		AT	150 minutes/wk						decreased BG levels post meal			
Hills, AP, et al.,[39]	2010	Resistance training for obese, type 2 diabetic adults: a review of the evidence	Limited external validity for certain ethnic groups and patients with T2DM	AT; RT		60-85% max VO_2 or max HR (AT); 60-	15-75 mins (AT)	Max: max HR (Age predicted)						

		(review)	age < 35			80% 1RM (RT)								
Krousel-Wood, MA, et al[25]	2007	Does home-based exercise improve body mass index in patients with type 2 diabetes? Results of a feasibility trial (RCT)	Potential confounding variables of other risk factors not assessed/controlled in the study. Diet was not controlled which could affect the results.	AT	5x/week		30 mins/day					3-6		
Lim, J.G., et al[26]	2004	Type 2 Diabetes in Singapore: The role of Exercise Training for its Prevention and Management (review)		AT		1000 kcal/wk					improved			
Madden K.M.[7]	2013	Evidence for the benefit of exercise therapy in patients with type 2 diabetes (Review)	Evaulate how different ethnic populations respond to the standard recommendations for exercise	AT			> 150 min a week						-0.89%	
Marwick,	2009	Exercise Training	Highest level of	AT (tread	5 days/w		20-30 mins							

T.H. et al[8]		for Type 2 Diabetes Mellitus Impact on Cardiovascular Risk (SR)	evidence since Systematic Review	mill)	k										
Misra ,A. et al.,[35]	2012	Consensus Physical Activity Guidelines for Asian Indians (Review)	Limited external validity to other populations	RT	> 3days/ wk	10 reps					> 70 - < 300				
Norris Susan , H., et al.[27]	2005	Long-term non-pharmacological weight loss interventions for adults with type 2 diabetes mellitus (SR)	The interventions in studies compared were hetergeneous limiting quantitative syntheses. Attrition bias; potential sampling bias because of small sample sizes	AT	2x/wk in group and 1x/wk on own; walked 3 miles 4x/wk	Moderate	3 miles		decreased	decreased			-1.0% to 2.6%		
Nyenwe, EA, et al.,[28]	2011	Management of type 2 diabetes: Evolving strategies for the treatment of patients		AT	3x/wk	Moderate	50 mins						-0.70%		

		with type 2 diabetes (review)												
Praet, SFE, et al.,[40]	2009	Exercise therapy in Type 2 diabetes (review)		AT; RT	3x/wk; no more than 2 consecutive days w/o activity	Moderate or vigourous (AT); 3 sets of 8-10 reps targeting all major muscle groups	150 min/wk or 90 min/wk		decreased 4.16		improved		improvement > 7.4%	
Riddell, MC, et al.,[29]	2011	Evidence-based risk assessment and recommendations for physical activity clearance: diabetes mellitus and related comorbidities (SR)	Conclusions about the probability of adverse events is limited because the many studies reviewed screened out patients with comorbidities or had s/s of myocardial insufficiency	AT (cycling)	5x/week	75% VO_2 max	30-40 mins/day, min. 20 mins sessions		< 260 mmHg	< 115 mmHg		< 6	-0.60%	10-13/20 or 3-6/10
Sigal, RJ, et al.,[13]	2004	Physical activity/exercise and type 2 diabetes		AT; RT (on all major muscle	3x/wk (AT and RT)	Moderate: 50-70% max	150 min/wk or 90 min/wk. 5 min		< 200 for people with neurop	decreased 2.58	>100			moderate

		(review)		groups)		HR or 40-60 VO_2 max. Vigorous: > 70% max HR or > 60% VO_2 max (AT); 1 set of 10-15 reps progressing to 3 sets of 8-10 reps of 1RM	warm up and cool down for AT and RT		athy; decreased 3.84					
Stewart, KJ, et al.,[41]	2004	Role of exercise training on cardiovascular disease in persons type 2 diabetes and hypertension (review)		AT; RT	2x/wk	Target 55-79% max HR or 50-60% if low fitness level (AT). Light to moderate: 30-50%	1 sets minimum of 8-10 reps						-0.66%	

						1RM								
Sukala, WR.,[42]	2012	Exercise intervention in New Zealand Polynesian peoples with type 2 diabetes: Cultural considerations and clinical trial recommendations (review)	High attrition rate and low intervention adherence rate	AT (cycle ergometer); RT (8 different muscle groups)	3x/wk	65-85% HR reserve (AT); 6-8 reps, 1 min rest between sets	40-60 mins							"very hard" or 17/20
Waryasz, GR.,[43]	2010	Exercise prescription and the patient with type 2 diabetes: A clinical approach to optimizing patient outcomes (review)		AT (tai chi, yoga, walking); RT	5x/wk total of AT and RT; 10 miles walking/wk (AT)	40-70% VO_2 max (AT); Low to moderate: workloads 50-74% 1 RM. High: >74% 1RM	minimum 30 min/day. 60-90 mins/day (For wt loss or maintenance)							11-15 "light - hard"
Weltman, NY, et al.,[44]	2009	The use of exercise in the management of type 1 and type 2 diabetes (review)		AT; RT (all major muscle groups)	3-5x/wk	Mod: 40/50 to 85% of HR reserve. Vig: 64/70 % to	150 mins/wk moderate intensity OR 75 min/wk at		decreased	decreased	> 100 - < 300			12-16

						94% of HR max (AT); Moderate to high of 8-12 reps	vigorous intensity. > 10 mins sessions.							
Whyte, J, et al.,[45]	2013	Exercise for patients with diabetic peripheral neuropathy: Getting off on the right foot (review)		AT (brisk walking, swimming, stationary biking, ellipitical); RT (legs, chest, back)	3x/wk. Aim for 150 mins/wk (AT); 2x/wk (RT)	40-60 VO_2 max (AT); mod to vigourous (RT)	Minimum 10 min bouts (AT); 5-10 exercises at 10-15 reps (RT)				decreased			
Younk, LM, et al.,[30]	2011	Exercise-related hypoglycemia in diabetes mellitus (review)		AT	3-4/wk	50-70% VO_2 max	150 mins/wk				>100		-0.38 to -0.51	

Appendix H: Studies and reasons for exclusion from the systematic literature review

Reason for article exclusion: NOT an RCT, MA or Guideline n = 56

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Appendix I: Physiological Profile Data Sheet

(Note: This sheet can complement data attained via Electronic Medical Record)

Condition	Contraindications ☑	Signs and Symptoms of Contraindications	☑	Exercise Prescription Options
T2DM	Autonomic neuropathy ☑	• Dizziness and fainting. • Urinary problems • Sexual difficulties • Difficulty digesting food • Sweating abnormalities • Sluggish pupil reaction • Exercise intolerance	☑ ☑ ☐ ☐ ☑ ☐ ☑	Type: Aerobic Training Intensity: moderate Frequency: 3-7 days per week Duration: 30-60 minutes per day Type: Resistance Training (major muscle groups ~ 8 exercises) Intensity: 30-70% of one repetition maximum Frequency: 1-4 sets, of 5-15 repetitions per exercise Duration: 2-3 days per week
	Severe peripheral neuropathy ☐	• numbness and tingling in feet or hands; may spread into legs and arms • Sharp, jabbing or burning pain • Extreme sensitivity to touch • Lack of coordination/falling • Muscle weakness or paralysis	☐ ☐ ☐ ☐ ☐	
	Pre-or-Proliferative retinopathy ☐	• Spots/dark strings floating in your vision (floaters) • Blurred vision • Fluctuating vision • Impaired color vision • Dark or empty areas in you vision • Vision loss	☐ ☐ ☐ ☐ ☐ ☐	
CAD	Unstable Angina ☐	• Chest pain or discomfort • arms, neck, jaw, shoulder or back pain with chest pain • Nausea • Fatigue • Shortness of breath • Sweating • Dizziness	☐ ☐ ☐ ☐ ☐ ☐ ☐	Type: Aerobic Training Intensity: moderate Frequency: 3-7 days per week Duration: 30-60 minutes per day Type: Resistance Training (major muscle groups ~ 8 exercises) Intensity: 30-70% of one repetition maximum Frequency: 1-4 sets, of 5-15 repetitions per exercise

				Duration: 2-3 days per week
	Uncontrolled arrhythmia ☐	• A "fluttering" sensation in chest • A racing heartbeat (tachycardia) • A slow heartbeat (bradycardia) • Chest pain • Shortness of breath • Lightheadedness • Dizziness • Fainting (syncope) or near fainting • Fatigue	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	
	Heart failure ☐	• Shortness of breath that makes it difficult to talk or finish an activity • Unusual or excessive fatigue, weakness or faintness • Pulse feels fast or irregular, or sensation of feeling the heart beat • Waking in the night coughing, feeling short of breath or gasping for air • Sudden or unexpected weight gain • Dizziness or light-headedness • Swollen feet, ankles, fingers, legs or abdomen • Need to urinate frequently at night • Loss of appetite	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	
	Stenotic/uncompensated valve ☐	• Chest pain (angina) or tightness • Feeling faint or fainting with exertion • Shortness of breath, especially with exertion • Fatigue, especially during times of increased activity • Heart palpitations — sensations of a rapid, fluttering heartbeat • Heart murmur	☐ ☐ ☐ ☐ ☐ ☐ ☐	
	Hypertrophic obstructive	• Shortness of breath,	☐	

	cardiomyopathy ☐	especially during exercise • Chest pain, especially during exercise • Fainting, especially during or just after exercise or exertion • Sensation of rapid, fluttering or pounding heartbeats (palpitations) • Heart murmur, which a doctor might detect while listening to your heart	☐ ☐ ☐ ☐	
COPD	Severe HTN ☐	• Severe chest pain • Severe headache, accompanied by confusion and blurred vision • Nausea and vomiting • Severe anxiety • Shortness of breath • Seizures • Unresponsiveness	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	Type: Aerobic Training Intensity: moderate Frequency: 3-7 days per week Duration: 30-60 minutes per day Type: Resistance Training (major muscle groups ~ 8 exercises) Intensity: 30-70% of one repetition maximum Frequency: 1-4 sets, of 5-15 repetitions per exercise Duration: 2-3 days per week
	Hypoxemia ☐	• Blue or cherry red skin tone • Confusion • Cough • Fast heart rate • Rapid breathing • Shortness of breath • Sweating • Wheezing	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	
	Unstable angina ☐	• see CAD unstable angina		
	Congestive hearth failure ☐	• see heart failure		

Summary of the algorithm aimed to process the physiological profile data

Condition→Screen Contraindications (from EMR/questionnaire/diagnostics)→screen Signs and symptoms→contraindications cleared→ Exercise Prescription based on physiological profile:

Type: AT, RT (all major muscle groups ~ 8 exercises); AT+RT
Intensity: AT=moderate; RT: 30-70%of 1 repetition max
Frequency: AT=3-7 days per week; RT: 1-4 sets, 5-15 repetitions
Duration: AT=30-60 min per day; RT: 2-3 days per week

Contraindications NOT cleared→Guide client to resolution options (Pharmacological; Surgical; Medial consult; Counseling; Alternative Medicine)→IF contraindication cleared proceed to exercise prescription→IF contraindication cannot be cleared provide safe alternatives (e.g., symptom free and unstructured activity such as walking, gardening, etc.)

Appendix J: Sample of a personal profile questionnaire

Please check off all appropriate boxes.

1) Postal Code
2) To attend appointments I am willing to travel:
   - ☐ ≤ 5 km
   - ☐ 6-20 km
   - ☐ 21-40 km
   - ☐ 51- 100km
   - ☐ >100km
3) To attend appointments I:
   - ☐ drive
   - ☐ use the transit
   - ☐ am driven by a special transit service provider (e.g., Wheel-trans)
   - ☐ use taxi services
   - ☐ am driven by my friend/family/other

Note: GPS technology can be employed to guide the use of data collected from questions 1-3. For example clients can be directed to an appropriate services in their community within a designated radius depending on client's mode of transportation and the distance they are willing to travel to attend appointments.

4) Employment status
   - ☐ full-time employment
   - ☐ part-time/casual employment
   - ☐ unemployed
   - ☐ on ODSP (Ontario Disability Support Program
   - ☐ on welfare
   - ☐ student
5) How much can you afford to spend on an exercise intervention:
   - ☐ $0.00
   - ☐ $ <500/year
   - ☐ $ 500-1000/year
   - ☐ $ >1000/ year

Note: Question 4-5 may inform the exercise options available to the client, (e.g., free, government-funded, private care)

6) Age Range
   - ☐≤18
   - ☐ 19-65
   - ☐>65
7) Activity preference. If you were to exercise what would you prefer:
   - ☐ exercising in a group
     - ☐ males only
     - ☐ females only
     - ☐co-ed
   - ☐ individual exercise

- ☐ by myself at home with appropriate instructions (written or digital)
- ☐ in an appropriate facility (e.g., gym, community center)
- ☐with an appropriate instructor (one-on-one)

- ☐ aerobic exercise
  - ☐ running
  - ☐ cycling
  - ☐ swimming
  - ☐ sports (tennis, volleyball, basketball, etc.)
  - ☐ other
- ☐ resistance training
  - ☐ lifting weights
  - ☐ calisthenics (using own body weight: lunges, sit-ups, push-ups, squats)
- ☐ combined exercise
  - ☐ circuit training
  - ☐ mixing different aerobic and resistance training activities
  - ☐ other (yoga, stretching, tai-chi, etc.)

Note: data collected by questions 6 may inform clients' eligibility for certain exercise interventions that are designed for a certain age-range (e.g., senior classes), while question 7 aims to collect data regarding client's activity preference to inform the clinician when designing a tailored exercise prescription.

Appendix K: Exercise Curricula Questionnaire

Copy of the electronic questionnaire that was e-mailed to physiotherapy, nursing, and medical program directors across Canada.

Unless otherwise indicated, please provide one response to each question. For the "Other (Please Specify)" option(s) you may provide as much information as you feel is necessary to reflect your thoughts as there are no word limits. Please note that "we/our" in this survey refers to the perspective of your professional program (e.g., medical, nursing, physiotherapy) at your institution (e.g., Western, UofT, Queens, McGill, etc).

1. We believe that giving advice to be physically active is the same as providing a specific exercise prescription:
   ☐Strongly Agree ☐Agree ☐Do Not Know ☐Disagree ☐Strongly Disagree
2. We believe that teaching students how to prescribe exercises to clinical populations should be mandatory:
   ☐Strongly Agree ☐Agree ☐Do Not Know ☐Disagree ☐Strongly Disagree
3. We teach students **how to design** an exercise program for individuals living with medical conditions.
   ☐Strongly Agree ☐Agree ☐Do Not Know ☐Disagree ☐Strongly Disagree
4. We teach our students to prescribe exercise(s) using specific criteria (e.g., frequency, intensity, sets, repetitions, duration, etc.)
   ☐Strongly Agree ☐Agree ☐Do Not Know ☐Disagree ☐Strongly Disagree
5. We teach our students **how to implement** an exercise program.
   ☐Strongly Agree ☐Agree ☐Do Not Know ☐Disagree ☐Strongly Disagree
6. We teach our students established exercise **precautions**.
   ☐Strongly Agree ☐Agree ☐Do Not Know ☐ Disagree ☐Strongly Disagree
7. We teach our students established exercise **contraindications.**
   ☐Strongly Agree ☐Agree ☐Do Not Know ☐ Disagree ☐Strongly Disagree

8. We teach our students what to monitor to ensure safety during exercise.
☐Strongly Agree ☐Agree ☐Do Not Know ☐ Disagree ☐Strongly Disagree
9. In order to teach our students specific physical activity recommendations, **we use exercise guidelines** from the following (check all that apply):
☐ We do not use any established guidelines
☐ American College of Sports Medicine
☐ Canadian Physical Activity Guidelines
☐ Canadian Society for Exercise Physiology
☐ Other (please specify)
10. Our students are taught how to advise patients about the benefits of exercise:
☐Strongly Agree ☐Agree ☐Do Not Know ☐ Disagree ☐Strongly Disagree
11. We have dedicated lectures to teach our students the physiological effects of exercise on chronic disease(s):
☐Strongly Agree ☐ Agree ☐Do Not Know ☐Disagree ☐ Strongly Disagree
12. We teach our students how to prescribe exercises to populations living with the following (check all that apply)
☐Type I Diabetes
☐Type II Diabetes
☐Coronary Artery Disease
☐Stroke
☐Multi-System Involvement ☐Other (please specify)
13. We have **at least one course** dedicated to teaching students about the benefits of physical activity/exercise:
☐Strongly Agree ☐Agree ☐Do Not Know ☐ Disagree ☐ Strongly Disagree
14. Exercise prescription is integrated within mandatory courses:
☐Strongly Agree ☐Agree ☐Do Not Know ☐Disagree ☐Strongly Disagree
15. Our curriculum provides a sufficient amount of exercise/physical activity instruction:
☐Strongly Agree ☐Agree ☐Do Not Know ☐ Disagree ☐ Strongly Disagree
16. In the next 5 years we plan to have a course dedicated to teaching our students how to prescribe exercise/physical activity to clinical populations [i.e., individuals living with chronic condition(s)]
☐Yes ☐ No ☐ We already have such a course ☐ Do Not Know

☐Other (please specify)

17. Please indicate the province where your institution is situated and share any additional thoughts/comments.

Appendix L: Curriculum Vitae

CURRICULUM VITAE

NINA HOVANEC

PREPARED: JULY 15, 2015

1. EDUCATION

Degree	Program	University	Location	Completion Year
PhD (c)	Health and Rehabilitation Sciences	Western	London, Canada	2015
MPT	Physical Therapy	Western	London, Canada	2013
MSc	Health Promotion	Western	London, Canada	2010
BSc (Honours)	Kinesiology	York	Toronto, Canada	2007

2. ACADEMIC CONTRIBUTIONS AND ACTIVITIES

Masters of Physical Therapy Admissions Committee-Application Reviewer

Responsibilities: One of 3 reviewers assigned to review a set list of application letters, references, scholarships. Reviewed and scored applicants' qualification for entrance into the Masters of Physical Therapy program at Western, University. (April 2015)

Research Co-Supervisor with Dr. Anthony A. Vandervoort

Responsibilities: conceptualized research study design; secured & supervised the research team, ensured the team successfully met all project demands and deadlines. (Fall 2013 – Summer 2014)

Research/Teaching Assistant:

1) The Impact of Inter-professional Team Development Education on Inter-professional Collaboration between Human Service and Nursing Students on an International Placement". 01/11 – 08/11
(Fanshawe College, London, ON)
RA Responsibilities: coordinated study members' participation, administered & collected information letter/consent/surveys; conducted

and recorded focus group sessions; completed data-entry and statistical (descriptive) analysis.

2) "Integrated Assessment in Physical Therapy". 09/10 – 12/10
Western University)
TA Responsibilities: preparation of lab materials, lectured first year physical therapy master's students on some of the course content, assisted the professor in answering students' questions, proctored exams, data entry and tabulation of all student examination scores.

3) "Management Knowledge Transfer in Healthcare". 2008 – 2010
(McGill University)
RA Responsibilities: collaborated with a number of multi-disciplinary researchers and professionals from McGill, Western, and Ottawa. Completed psychometric analysis of identified knowledge transfer tools from health management research journals; summarized content within the identified tools' template to enable healthcare professionals and researchers to draw from a pool of psychometrically sound measures for effective practice.

4) "Planning, Implementing, & Evaluating Health Promotion Programs". (Western University, London, ON) 09/09 – 12/09
TA Responsibilities: proctored all exams, held office hours to address student questions and concerns.

5) "Knowledge Flow and Exchange in Interdisciplinary Health Care Teams". (Western University, London, ON) 09/08 – 12/08
RA Responsibilities: administered letters of information, consent forms, conducted in-depth interviews with study participants (e.g., family health team members).

6) "Client Network Analysis". 01/08 – 05/08
(Ontario Physical Activity and Health Education Association)
RA Responsibilities: helped code 1000 survey responses from OPHEA's client network (health promotion personnel, educators, recreation leaders); verbatim analysis of the network's multi-layered responses used by the board and senior management staff at OPHEA to effectively develop its 3-5 year strategic plan. (Toronto, ON)

7) "Long Live Kids Campaign and Healthy Active Living Program" (Concerned Children's Advertisers) 01/08 – 05/08
RA Responsibilities: 1) *Formative Research*: helped in the development of focus group and interview content for educators across the Greater Toronto Area; secured educators for participation and conducted focus groups & interviews alongside Professor Michelle Brownrigg. 2) *Evaluative Research*: developed a data extraction template for nationally collected evaluation forms 2006. Developed a report of key findings made available to 20+ member organizations at their AGM (Toronto, ON)

3. LIFETIME SCHOLARLY ACTIVITY

A. PUBLICATIONS

1) **Hovanec N**, Overend T, Vandervoort A. Exercise curricula in Canadian physiotherapy, nursing, and medical schools. *Jacobs Journal of Physiotherapy and Exercise* 2015, 1(1): 006 (published)
2) Kothari A, **Hovanec N,** Sibbald S, Donelle L, Tucker T. Process Evaluation of Implementing Knowledge Management Tools in Public Health. *Knowledge Management Research & Practice 2015* (published).
3) **Hovanec N**, Bellemore D, Kuhnow J, Miller F, van Vloten A, Vandervoort A. Exercise prescription considerations for individuals with multiple chronic diseases: Systematic Review. *Gerontology & Geriatric Research* 2015; 4:1, pp.1-10 (published)
4) **Hovanec N**, Sawant A, Oerend TJ, Petrella RJ, Vandervoort AA. Resistance training and older adults with type 2 diabetes mellitus: strength of the evidence. *Journal of Aging Research* 2012; 2012, pp. 1-12 (published)
5) Kothari A, **Hovanec N**, Hastie R, Sibbald S. Knowledge management in health care: lessons from the business sector. *BMC Health Services Research 2012* (11): 173 (published)
6) **Hovanec N,** Overend T, Vandervoort A. The *how* of exercise prescription in primary care: a proposed approach (in preparation).

B. PRESENTATIONS

1) Discussion Panel Member: presentation of experiences gained as a community physical therapist working with marginalized communities in Toronto. Answered fourth year undergraduate students' questions and contributed to the overall discussion. (York University, Health Promotion Course, Toronto, ON) — 16/08/15
2) Poster Presentation: Bellemore D., Kuhnow J, Miller F, van Vloten A, **Hovanec N**, Vandervoort AA. "A novel systems-based approach using physiological markers from CAD, COPD, and type 2 diabetes for exercise prescription for individuals with multiple chronic diseases: systematic review." (Western University, London, ON) — 18/07/14
3) Poster Presentation: **Hovanec N.,** Overend, T., Petrella, R., Vandervoort, A. "Study Proposal for Exercise Prescription in Complex Patients". School of Physical Therapy Research Day. (Western University, London, ON) — 19/07/13
4) Oral Presentation: **Hovanec N.** "Strength of the Evidence, Resistance Training and Older Adults with Type 2 Diabetes". Health and Aging Seminar. (Western University, London, ON) — 04/04/11
5) Oral Presentation: **Hovanec N.** "A Project to Develop and Pilot Test Tools for Knowledge Management in Public Health Units". (The Tenth International Conference on Knowledge, Culture & Change in Organizations, Montreal, QC.) — 27/07/10
6) Oral Presentation: **Hovanec N.** "Knowledge Management Tools: An Introduction". (Huron, Clinton, Region of Peel, and York Region — 13/04 – 17/06

Public Health Units, ON)

7) Oral Presentation: **Hovanec N.** "Knowledge Management Tools: A pilot study in public health" (Public Health Unit, Huron, ON) — 05/05/10
8) Guest lecturer: **Hovanec N.** "Designing Evaluation: Types of Program Evaluation". (Western University, London, ON) — 11/01/10
9) Poster Presentation: Harlos, K., Kothari, A., Ritchie, J., Taylor, L., Angus, D., Baxter, J., **Hovanec, N.**, and Bird, M. "Using management knowledge to advance knowledge implementation in health care: scoping the literature". (Manitoba Centre for Health Policy 20th Anniversary Conference, Winnipeg, MB) — 08 – 09/03/10
10) Workshop facilitator: "Developing a Toolbox for Tacit Knowledge Management in Public Health". (Canadian Public Health Association 2009 Annual Conference, Winnipeg, MB) — 08/06/09

4 CLINICAL EXPERIENCE

A. EMPLOYMENT

Closing The Gap Healthcare Group (Toronto, ON) — 31/03/14 – Present

- Clinical Practice Context: Community **(**Physiotherapist)
- Responsibilities: assessments, diagnosis, treatment, discharges; improve clients' functional mobility through education, exercise prescription, and use of appropriate modalities; connecting and referring clients to necessary services; supervise PTAs.
- Caseload: diverse (people with MSK/orthopaedic/neurological/multi-system needs)

B. CLINICAL PLACEMENTS

West Perry Sound Health Center (Perry Sound, ON) — 07/13 – 08/13
Clinical Practice Context: Acute Care

Veterans Care Program, Parkwood Hospital (London, ON) — 04/13 – 06/13
Clinical Practice Context: Rehabilitation

CBI—Physiotherapy & Rehabilitation Center (London, ON) — 03/13 – 04/13
Clinical Practice Context: Orthopaedics/Clinics

Unit A3: Neuro-Oncology, St. John's Rehabilitation Center (Toronto, ON) — 10/12 – 12/12
Clinical Practice Context: Rehabilitation

Bruce County Physiotherapy and Sport Injuries Clinic (Port Elgin, ON)**; & Sauble Beach Physiotherapy Clinic** (Sauble Beach, ON) — 06/12 – 07/12
Clinical Practice Context: Orthopaedics/Clinics

5. DEVELOPMENT ACTIVITIES

In-service Training/Workshops 12/12 – 06/13

- Brain Gym—St. John's Rehabilitation Center (Toronto, ON)
- Kinesio Taping—Parkwood Hospital (London, ON)
- Vision Rehab—Parkwood Hospital (London, ON)
- Manual Muscle Testing—Parkwood Hospital (London, ON)
- Documentation/Record Keeping—Parkwood Hospital (London, ON)

Certification

- **Soft Tissue Release Certificate** (London, ON) 27/01/13
- **York University Sports Administration Association Certificate** (Toronto, ON) 06/2007
- **NDT/Bobath Certificate** (Toronto, ON) (Fall: 2015)

6. HONOURS

- Western Graduate Research Scholarship, Western University, Ontario 2008 — 15
- Graduate Teaching Award Nominee, Western University, Ontario 2010
- Dean's Honour Roll, York University 2007
- Customer Service Award, Shoppers Drug Mart 2007
- Entrance Scholarship, York University 2002

7. VOLUNTEER

- Mili Fay Art "Together we support the world one artwork at a time" 2011 – Present
- INFUSION Canada, a registered charity for cancer survivors 03/03/11
- William Osler Health Center Etobicoke Hospital Campus, Canada 05/05 – 08/05
- Dom Zdravlja (Health Center), Belgrade, Serbia 06/04 – 09/04

8. HOBBIES

- Recreational activities (I love contemporary dance, volleyball, tennis, being active)
- Meditation & Yoga (always helps me recharge, re-energize, and gain perspective)
- Finally, I love traveling, reading, socializing, the arts, and living life to the fullest!

PROFILE SUMMARY

- Member of the Canadian Physiotherapy Association (2011-present) in the following divisions: Orthopaedic, Neuroscience, Pain Science, Seniors Health.

- Proven ability to multi-task and complete high caliber projects.
- Achieved publications of highly accessed articles.
- Exceptional collaboration with clients and colleagues with over 10+ years of work experience as a member of diverse teams.
- One of two students accepted into the combined MPT/PhD at Western, 2010.
- Recognized for volunteering in different cultural and organizational contexts.