ISSUES & CHALLENGES FACING RECREATION PROVIDERS IN NEWFOUNDLAND AND LABRADOR

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By

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EXECUTIVE SUMMARY

Recreation providers face many issues and challenges, which make it difficult for them to provide recreational programs and services. The purpose of this report is to a) identify issues and challenges faced by recreation providers in Newfoundland and Labrador (NL); b) determine the importance of these issues and challenges; and c) discuss and highlight recommendations that could help overcome these issues and challenges in the field of recreation. This report was completed as my Applied Research Project as a component of my Master's in Physical Education degree within the School of Human Kinetics and Recreation at Memorial University under the supervision of Dr. Angela Loucks-Atkinson. This project was also informed by my professional role with Recreation NL. For the last five and a half years I have worked as Program / Marketing Officer for RNL

The participants identified for this study were recreation providers in NL and included paid municipal recreation practitioners and volunteers, as well as municipal councilors that represent recreation in their community. The data was collected using a web-based survey between March and May 2012. A total of 90 participants completed the survey. A facilitated break-out session, offered during RNL's 41st Annual General Meeting and Conference, was conducted in which approximately 75 participants took part.

This project gave the recreation providers of NL an opportunity to reveal all the issues and challenges they face. This report categorizes and discusses the top ten issues and challenges: budget, staffing, facilities, inclusion, planning, understanding and support,

marketing, partnerships, evaluation and professional development. Issues and challenges specific to NL are also presented. Findings of the study highlight the fact that all of the issues and challenges impact each other; with staffing, budget, facilities, and understanding and support having the most overlap. Therefore, one must consider these issues and challenges holistically rather than individually.

The response to the survey and facilitated break-out session of this report shows that recreation providers in NL want to be heard and also want to be engaged in terms of finding solutions to their issues and challenges. This report gives clear recommendations that will aid the NL recreation sector in improving and addressing each issue and challenge. The results clearly show that improved funding, increased staff, educational resources for decision makers, and professional development opportunities for staff would lead to significant improvements for each issue and challenge. It was also evident that recreation providers within NL look to RNL and the provincial government as the lead supporters for assistance and to provide these resources, as well as the municipality, funding providers and other provincial associations. The results of this study should be used to develop strategic plans, policies and procedures that will improve the field of recreation within NL. It is recommended an evaluation of this nature be conducted every three to five years to track the improvements and changes, as well as any new or growing issues of the recreation sector in NL.

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1.0 INTRODUCTION

"Recreation is defined as, an activity that individuals participate in during their free time for fun or pleasure, which contributes to an overall satisfying and increased quality of life. While these activities may mean different things to different people, it is an activity specific to their needs and wants. What is recreation to one person may be work to another, depending on their preferences. By engaging in a stimulating or amusing activity, it helps you refresh your body and mind" (www.recreationnl.com, n.d.).

There are numerous benefits to individuals engaging in positive recreation: social, physical, mental and emotional. Recreation is not confined solely to sports and physical activity; it includes artistic, cultural, social and intellectual activities. It is a social service in the same way that health and education are considered social services. Community recreation doesn't just assist individual development and quality of life but community development and social functioning as well (Recreation Newfoundland & Labrador presentation, 2011).

Trying to offer the variety of recreation opportunities to satisfy the needs of the individuals in a community is a challenging endeavor; this is the task of the local recreation provider. Recreation providers offer opportunities for individuals to participate in during their leisure time and to help participants experience enjoyment and live healthier lives as a result of the benefits gained from recreation experiences. Unfortunately, having to deal with the various professional issues can make the task even more challenging. These challenges include lack of funding, lack of facilities

(Connaughton, DaMichele, & Zhang, 2004) and retaining staff and volunteers (Brown, Yoshioka, & Munoz, 2004).

The needs of recreation organizations are vast; obstacles may be dependent on the organization and the local area. According to Recreation Newfoundland and Labrador's (RNL) 2012 membership there are approximately 50 volunteer commissions and 35 recreation departments in NL. The majority of communities with a dedicated recreation department have a small number of staff, often of three or less, and are only able to hire extra staff on a seasonal basis for program support.

Recreation providers face many issues and challenges. The purpose of this report is to a) identify issues and challenges faced by recreation providers; b) determine the importance of these issues and challenges; and c) discuss and highlight recommendations that could help overcome these issues and challenges in the field of recreation. This report was completed as my Applied Research Project as a component of my Master's in Physical Education degree within the School of Human Kinetics and Recreation at Memorial University under the supervision of Dr. Angela Loucks-Atkinson. This Project was also informed by my professional role with RNL. For the last 5.5 years I have worked as Program / Marketing Officer for RNL. I believe that my experience working with recreation providers (practitioners and volunteers) in NL was beneficial to this study. Having an "insiders" perspective allowed me to be sensitive to the concerns and issues of privacy and confidentiality of the participants involved. My professional role also provided me with applied knowledge of issues and challenges faced by recreation providers in the province.

2.0 LITERATURE REVIEW

Recreation practitioners face many issues and challenges in their day-to-day jobs. A review of peer-reviewed journal articles was conducted to identify the major issues and challenges faced by recreation practitioners. It should be noted that limited research has been conducted in recent years, which specifically examines professional issues within public recreation. From what empirical research does exist, the literature review resulted in the identification of several issues and challenges (see Table 1).

Table 1: Ranking of Recreation Professional Issues Identified in Literature Review

1.) Budget (lack of funding) – in multiple areas
2.) Staffing (Quality workers – staff and volunteers)
3.) Facilities – lack of, outdated, non-inclusive
4.) Inclusion support
5.) Planning – long term (mission statement)
6.) Understanding and support – from public and decision makers
7.) Partnerships
8.) Marketing / promotion/ communication
9.) Evaluation (needs assessment)
10.) Professional development support

2.1 BUDGET

Public recreation users expect quality programming, services and facilities; this is challenging for recreation professionals to maintain with budget constraints (Maynard, Powell, & Kittredge, 2005). Financial hardships affect recreation agencies at one time or another whether it is due to funding cut backs or increased cost. Therefore, agencies need to be creative in how they deal with this challenge. Some agencies have privatized services or initiated revenue-producing activities such as seeking donations and hosting

fundraiser events. Others have tried to do the following to address budget constraints: increasing user fees; reducing operating cost; and seeking additional and alternative funding (Connolly & Smale, 2001/2002).

When budgeting for programs and services the practitioner must first consider the agencies operating cost. All or some of this cost of a program or service can be recovered through the user fee(s) (Johnson, Tew, Havitz, & McCarville, 1999). Setting the price for the user fee(s) can be a delicate decision as many users look at the price as their first indicator for quality; higher prices may convey high quality and induce purchase by some, but unfortunately may create a barrier for others. Therefore, the practitioner needs to try to recover the operating cost without setting the fee too high for the target market and not too low to devalue the program to potential users (Connaughton, DeMichele, & Zhang, 2004).

All expenses of a program, service or facility should contribute to the agency's ability to satisfy the participants experience in the recreational opportunity being delivered. The quality of the program or service must be considered when looking to reduce operating cost to overcome a financial problem. Reducing cost can result in low quality programs, services and facilities that are publicly frowned upon. Reducing expenses in areas such as maintenance scheduling and purchasing of supplies and equipment results in lower quality programs and services, decrease in users and can jeopardize safety (Maynard, et al., 2005).

There are funders that supply grants that are available for practitioners to apply for in order to finance programs. Most grants are usually designed for a particular population or a specific type of program to address a defined need as outlined in the regulations of

the grant application. Therefore, the grants available may not be a direct fit to the program an agency requires to address the need in the community. The practitioner must then decide to either apply for the grant as specified or attempt to revise the community needs to some extent to eligible for available funding. Being able to write a successful application involves being able to position the needs in the community with the outlined intent of the grant as well as writing the application in the format required. It is important then that recreation practitioners make the time and focus on the task of grant writing to increase an agency's chances of being awarded such grants (Barnes & Brayley, 2006). Additional writing is needed for some grants because they require a written report after the program/event has been completed outlining how the funds were used.

When budgeting for recreation programs and services there are many factors to take into consideration: the quality and safety of the program or service being delivered as well as, the possible funding grants available. There are crucial issues for the practitioner to be aware of and there are things he/she should be striving to maintain / improve. Organizations need to be aware of the risks they face when programs or services are not priced appropriately and the operating costs are reduced too low. The organization and the recreation practitioner need to work together to seek additional funding, giving the practitioner the resources they need to effectively apply to grant opportunities, or they need to work together to find other ways of balancing the finances.

2.2 STAFFING

Recreation organizations have program staff to help with the day-to-day work of preparing and delivering programs and services to the community. Organizations, especially not-for-profit, may also seek volunteers to help with program and event delivery. Additional workers, whether paid or volunteer, can be crucial to the amount, variety and quality of recreational opportunities an organization is able to provide. Both the program staff and volunteers usually work under the leadership and supervision of the recreation practitioner. The practitioner has the responsibility of creating positions and seeking out workers to fulfill them; ensuring workers have the necessary competences to do the job effectively and are satisfied in their position in order to manage employee turnover.

Recreation staff and volunteers require a unique set of competences. There is no written set of essential skills, knowledge, abilities, or personal characteristics that has been defined for recreation workers. An organization may streamline the competences by defining their position and job description. It is expected that a person with an education in recreation, degree or diploma, should have the basic skills to perform well in an entry-level position; working with the participants, program planning and coordinating (Hurd, 2005). Therefore, practitioners need to have an understanding of the skills being taught to recreation students in different post-secondary institutions, to ensure that they have the expected skills.

Similar to the employed and volunteer staff, having a Board of Director's with the necessary competencies is crucial to an organization. The Board of Directors is a major

part of the organization, and their performance is pivotal to the effectiveness of the organization (Hurd, 2005). A recreation practitioner has to be able to work with and seek advice and take direction from qualified people sitting on the board who understand the recreation sector. The members of the board should understand not only the overall organization but also the work of the practitioner including the time needs, support and requirements for practitioners to do what is asked of them.

Staff and volunteers may be attracted to work/volunteer at an organization for a variety of reasons. Some may be attracted by the organization's mission statement/mandate and others for the type of work they get to perform in their position; but the worker must be satisfied in the position to stay with the organization. Employees may decide to leave an organization for many different reasons. According to a study by Brown, Yoshioka, and Munoz (2004) examining employee retention, pay satisfaction was the fundamental reason why an employee decides to leave or stay. Whereas volunteer satisfaction is the interaction between function and job setting. Volunteers need to enjoy their role and feel appreciated for the time they donate. Therefore, practitioners need to work with each volunteer to understand why they want to volunteer and place them accordingly within the organization (Brown, et al., 2004).

Satisfied employees and volunteers are more likely to commit to the organization, set higher performance goals, and maintain better performance levels. However, as discussed above workers leave for a variety of reasons (Connaughton, DeMichele, & Zhang, 2004). When a worker leaves, the organization posts the job opportunity and fills the position. Whether the new hire is someone who has an education in recreation or just an interest in the field / organization, there may be a need additional training in

specialized areas that relate to the position. Training new workers can be very beneficial for an organization but also requires dedicated funds and can be very costly for the organization.

2.3 FACILITIES

Some recreation practitioners are recreation facility managers. A recreation facility can range from an arena, a swimming pool, bowling alley, gymnasium, a multi-purpose structure, and so forth. These facilities sometimes have a target user group, such as youth or older adults or it may incorporate the entire community. It is the practitioners job to know the recreational needs of the community and the facility operations, therefore they are knowledgeable to assist in the development, design and planning of new facilities and facility upgrades. Practitioners who work in facility management positions require a variety of skills, knowledge and support in the following areas: budgeting, maintenance, risk management, staffing, operation and development (Recreation Directors Handbook, Manitoba, 2008). Unfortunately gaining these supports and knowledge can become challenging for practitioners.

As previously discussed, budget constraints are a major challenge when trying to offer the needed recreational opportunities of a community. A facility can have many benefits including adding additional recreation opportunities to the existing variety within a community and by creating more space for programs to grow. Users expect high quality facilities whenever they are looking for recreational services, but unfortunately the cost associated with facility development and maintenance can sometimes outweigh the

benefits of the facility itself (Recreation Directors Handbook, Manitoba, 2008). If a facility isn't cost effective, there may a need for financial support to subsidize the operations. If the support isn't available then it can become too costly for users. This can be challenging for practitioners to balance, as there are many things to consider when setting user fees. The financial support to subsidize the cost of operations requires time, planning and dedicated funds.

A high quality facility is a facility where users shouldn't question their safety. Facility managers have to ensure the safety of everyone within the facility at all times. To do this they need to establish safety regulations, rules and expectations. Some facilities have more potential risk than others. Creating a risk management program to identify and control potential risks or hazards, can also be costly but are essential to the operations. This also links to the issue of professional development section (Recreation Directors Handbook, Manitoba, 2008).

Users not only want to feel safe when using a facility they are looking for quality programming in a welcoming, comfortable environment. Staff members play a large role in creating that environment. Staffing for facility operations is another important component of facility management. Practitioners should know the skills needed to operate all the necessary equipment and hire the correct personnel to do so. They must also ensure workers have the required certification / education to do the job efficiently.

Although there are challenges in the management and operations of recreation facilities, the number one issue is the lack of facilities. Many communities have a need for either their first or an additional facility or require facility upgrades or maintenance. Practitioners understand the needs of a community and are knowledgeable about the need

for a facility in a community, for example: pool vs. arena and additional multi-purpose features such as meeting space or a walking track. Unfortunately decisions about facility development are sometimes made without the practitioner's involvement. This can create challenges and problems such as the ability for the facility to be cost effective and efficient and the ability of a facility to include the space, features and equipment necessary to meet the needs and demands of current and future programs and users. The structure being physically inclusive to all the needs of the community is also an important issue including site location, mobility assistance and layout. Practitioners should be included from concept to completion of facilities and be involved in the strategic planning process to ensure consistency throughout all aspects of facility development and management. Planning will be discussed in more detail in another section.

Facilities are needed in order to meet the needs and demands of the community. Practitioners require space and specialized facilities, such as swimming pool or a gymnasium, in order to offer the programs and services that are desired. As experts in the field, practitioners appreciate being able to participant in all stages of facility development, from concept to completion. They have to be involved and/or understand all aspects of the facility from budgeting, risk management, operations, and development. The necessary supports including financial, staff and plans need to be in place to ensure a quality facility and recreational experience for all users.

2.4 INCLUSION

Most practitioners are required to serve the whole population of a given community or area. They conduct needs assessments to gather information on the community to better understand each individual wants, needs and potential barriers. By understanding the needs of the community the practitioner is able to provide recreational opportunities that are inclusive for all, as all individuals have the right to freely choose if, when, where, with whom, and how they participate in recreation environments and experiences (Scholl, Glanz, & Davison, 2006).

A facility should be accessible to everyone that would like to participate. This means all the needs of the community should be taken into consideration in all aspects of the facility including location, access to and from the location, the physical structure (doorways, ramps, etc.) and user fees. For a facility's location to be completely inclusive the location would be an area that is central and accessible be all means of transportation, including walking and public transit. The physical structure of a facility should not only meet the building codes, but be looked at through the eyes of a participant to determine what would be the most convenient and customer friendly; for example having the height of the counters appropriate for children and individuals in a wheelchair or having the elevator next to the stairwell so those who need to use it don't feel excluded. These are just some examples of how an inclusive facility can facilitate enjoyable experience for participants.

From a needs assessment practitioners learn about the financial situations of the households in the community, giving the practitioner an understanding of how much a

family may be able to afford and an indication of what to set the prices for programs and services. Recognizing the financial limitations in a community is very important to providing opportunities that are inclusive for all. However, as discussed earlier managing a cost effective facility can be difficult. Keeping prices low isn't always achievable; offering reduced rates and subsidy programs for participants that need financial support are examples of ways to ensure all individuals have a means to participant in all recreational opportunities (Tirone, 2003/2004).

Some individuals within a community may have other personal needs that they require assistance with in order to participate and enjoy a recreational opportunity to the fullest. These can also be identified through both a needs assessment and the registration process. Personal assistance may require physical, behavioral or communicative support. The program staff may require training to gain knowledge, sensitivity and skills to work with diverse populations.

2.5 PLANNING

Planning relates to many other issues raised in the review of literature, as having a plan helps guide all aspects of an organization or department. Without comprehensive plans, discussions may become disjointed and reactive. There are many different levels of planning; there are plans, which assist with the future direction and decisions of an organization as well as assist with making the day-to-day operations of the organization easier. These plans are: strategic, operational and programming or project planning. Many community recreation strategic plans are comprehensive and require community

involvement, visions, dreams and strategies for recreation in the next few years. Development of large plans can take time, skills, community cooperation, a budget and an evaluation process.

Time is often the main issue for not planning; to plan properly practitioners need dedicated time to research past and possible future directions and decisions. When in the planning process it is important to progress and start implementing the plan as soon as possible. Unfortunately many times the day-to-day operations get in the way of the planning process by either prolonging it or preventing it from starting. Many organizations and departments don't have the needed staff support to properly plan.

Developing comprehensive community or operational and program / project plans requires knowledge and skills in the area of planning. For example, strategic planners must be able to work with and develop information from the whole community including the staff, recreation committee / commission, partner organizations and the general population. Whereas, operational and program / project planners must be able to connect with the direction of the strategic plan and have knowledge of time, space and recreation management, to ensure that all areas of the organization or department sync together.

Planning is not achievable without a dedicated budget to support it. It is necessary to assist practitioners with the support staff, materials and training to plan efficiently. Professional development opportunities to improve planning skills are required. The more knowledgeable practitioners are about planning, the more efficient they will be in developing a plan that is cost effective and ensures quality and safety. Funding may also be used to help gain community involvement in the planning process making it interesting, enjoyable and rewarding for all those involved. Some organizations go to the

participants; either to their homes or public areas, such as shopping centers. They may also provide incentives, or hold public gatherings with refreshments and thank you items. In addition to support staff for operations and programs, there can also be a need for additional staff to assist in the planning process; this can help relieve pressure from the practitioner and assist with gaining necessary skill sets.

2.6 UNDERSTANDING & SUPPORT

Recreation is a widely used term used in many situations but unfortunately the field of recreation is not well understood by the general public. Recreation includes a wide variety of opportunities and experiences that can provide many benefits for participants, however recreation is often misunderstood for health or sport, as many community health and sport opportunities are offered by or through the community recreation provider. Additionally, perhaps due to this lack of understanding and support recreation is not considered an essential service and thus is often overlooked and undervalued in budgeting decisions. This misunderstanding leads to practitioners having to explain and position themselves and the programs and services they offer to gain appreciation and support.

Recreation practitioners do not always receive support because they are misunderstood. It is the role of the practitioner to qualify the importance of recreation programs or services for a community, the role of the participant to qualify the benefits they gain through their experience and the role of provincial and post secondary institutions to assist the practitioners and advocate on their behalf. Recreational programs

and services are expected but are not always supported; support providers need to understand the importance of, and requirements needed for practitioners to meet expectations.

2.7 PARTNERSHIPS

Partnerships combine the strengths and resources of a variety of organizations, and have been identified as key to providing successful programs. They help eliminate duplicate programs, encourage shared responsibility, generate more ideas and strategies, involve more people in addressing issues and are expected from many funding agencies (Recreation Directors Handbook, Manitoba, 2008). While partnerships can be very positive and benefit a recreation organization or department they can also be challenging as the people involved have different ideas, personalities, goals, values, etc. These differences can create barriers and limitations to the partnership.

Partnership activities should facilitate the allocation of key resources toward improving recreation programs and service. The most important factor when entering a partnership is having a common goal, values and mission. As discussed in the section on planning, there are steps to follow when creating new initiatives: plan, implement and evaluate. This is also true with partnerships; the relationship should have an outlined purpose stating what each party will contribute. The relationship should also be evaluated and reviewed on a regular basis to ensure all parties still have the same goal or mission. Failing to do so can cause unnecessary challenges and if left too long before being addressed can complicate the quality of the program or service.

Partnerships can help eliminate duplicate programs and services, reduce operating costs, as well as eliminate competition between organizations. By combining the key strengths and resources of two organizations professionals can create better, high quality, and sometimes even cheaper recreational opportunities then either organization would be able to offer on their own. While partnerships can provide needed support for an organization or department, they can also create challenges and issues if not created and maintained properly. Often these challenges and issues can be avoided if the right measures are in place.

2.8 MARKETING

Practitioners create, plan, organize and coordinate programs and services but they need participants to come and take advantage of these opportunities. While some participants may come looking for these opportunities, others need to be told or reminded. Marketing is essential to promote the recreation opportunities being offered to the target market it is intended for. It is important to promote the importance of recreation and its many benefits to gain appreciation from the public for the programs and services that are available to them and gain support from key stakeholders. "People need to be informed, educated, inspired, motivated, sometimes persuaded and often reminded, to come to programs" (Recreation Directors Handbook, Manitoba, 2008, p.51). Marketing is complex; being able to recognize available promotional opportunities, knowing what to promote and how to communicate the message is important and can take time. Marketing

needs to be built into the plan process and requires written policies and procedures to be effective.

Planning, creating and delivering marketing strategies can be costly, time consuming and require special skills. Marketing resources need to stand out to be recognized by the public, and be in delivered in a manner that potential participants will notice and at the right time. For example, if promotions are published too late participants may not be able to attend, or if marketed too early that participants may forget. Marketing is an important component to any program and service so people know the opportunities that are available. Without adequate support and training practitioners will not be able to market successfully.

2.9 EVALUATION

A recreation need can be defined as the gap when what is considered a necessary level or condition is not being met by what is actually occurring (Nogradi, 2000). Recreation practitioners should assess the needs of their current and potential participants to understand the values and benefits they seek from the services in order to strategically manage these needs to maximize return. Because practitioner budgets come from public funds, they must be accountable for their decisions and actions and dedicated to providing needed services in the most efficient way possible. Community need assessments collect data that gives important information about what participants think about current programs and services and insight on the programs and services they would like to see in the future. The organization or department can use this information; planning,

implementing, evaluating, and justifying the programs and services they offer (Nogradi, 2000). Unfortunately need assessments are time consuming and can be costly. This stresses the importance of planning and building evaluation into the plan.

Recreation departments who are truly concerned about quality of life and service to the public, must be actively engaged in identifying and assessing needs and then utilizing this information to their full potential (Nogradi, 2000). Being able to communicate to the community how the department has found and fulfilled gaps will help participants see value in the opportunities being offered. In order to do this, practitioners need the tools and support to effectively evaluate programs and services.

2.10 PROFESSIONAL DEVELOPMENT

Professional development is very important for practitioners to increase and improve their skills, as well as to stay on top of current knowledge and trends. The challenge for practitioners is being able to take the time to attend professional development opportunities due to lack of support staff. Professional development can be costly, and require additional funding.

Training needs to be available to all if new ideas and thinking are to be implemented (Anderson, Fredrickton, & Dybiec, 1995). It also helps to remove barriers as co-workers understand a common knowledge, as well as increase job satisfaction and performance (Anderson, et al., 1995). Unfortunately as many departments have a small number of staff there isn't enough support staff to accommodate one being absent to attend training opportunities.

Professional development of staff should be considered in the budgeting process. Having well trained staff who are knowledgeable about the most up to date ideas, trends and resources can help benefit the department in the future. Benefits can result in better resources, quality programming, and ease and reduced costs of day-to-day operations. Unfortunately, when departments don't have adequate funding recreation professionals are not able to participate in training and professional development, which can have negative long-term effects of the organization and the community.

Professional development is an important part of any career, being able to improve existing skills and stay up to date on trends and resources is important in any field of employment. When organizations and departments invest in their staff it can improve employee morale and make the employee feel valued, resulting in higher productivity and a professional work environment. Recreation departments can benefit greatly by providing or supporting staff to participant in training opportunities.

3.0 RESEARCH METHODS

3.1 SAMPLING AND RECRUITMENT

The participants identified for this study were recreation providers in NL, paid municipal recreation practitioners and volunteers, as well as municipal councilors that represent recreation in their community. The participants were contacted via email and at events hosted by RNL.

3.2 SURVEY

The survey asked questions relevant to the recreation profession or their volunteer endeavors and identified issues/challenges facing recreation providers in the province (see Appendix A: Survey). Participants were sent an email through RNL membership database informing and inviting them to participate in a web-based survey. The survey was also available in print upon request or during events hosted by RNL. The web-based survey was hosted on Survey Monkey (http://www.surveymonkey.com/). Survey Monkey is a web-based survey site and tool that employs multiple layers of security to make sure that the survey account and data remains private and secure. They employ a third-party firm to conduct daily audits of their security, and the survey data resides behind the latest in firewall and intrusion prevention technology. Any data that is collected is kept completely and absolutely confidential. The web-based data was only accessible to the researcher and supervisor who have the password for the site. Survey data was collected between March

and May 2012 and a total of 90 participants completed the survey. Date analysis involved descriptive rather than inferential statistics.

3.3 FACILITATED BREAKOUT SESSION

Approximately 75 participants took part in the facilitated breakout session, which was offered as a session during RNL's 41st Annual General Meeting and Conference. At the one-hour facilitated breakout the participants were presented the findings of the survey. The purpose of the facilitated breakout session was to give participants an opportunity to comment and add to the issues/challenges presented as well as get them to work together on a series of questions (see Appendix B: Facilitated Breakout Session Interview Guide). Participants were randomly divided into groups of 8 to discuss and answer questions on 5 of the 10 issues / challenges: budget, staffing, facilities, inclusion, and marketing. In these working groups they had the opportunity to develop and suggest potential solutions and recommendations. Each working group discussed the issue they were given; one person recorded their responses. As the evaluator, I and an assistant were present and provided assistance to the groups if they needed guidance. The responses were sorted into categories and themes.

3.4 ETHICS APPROVAL

The proposal of this research was reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be compliance with Memorial University's ethics policy.

4.0 SURVEY SAMPLE DESCRIPTION

4.1 EMPLOYMENT STATUS OF RESPONDENTS

Respondents were asked to self-identify their employment status and select all categories that applied to them. As outlined in Figure 1, there were not many students, which is likely due to the sampling technique used. The highest percentage of respondents were full-time employees in the recreation field (55%), it is interesting to see that the second highest number of respondents were volunteers (34%). The majority of the volunteers identified that they have been volunteering for less than 5 years. It is important to note that the volunteers in the province are committed enough to complete a survey of this nature.

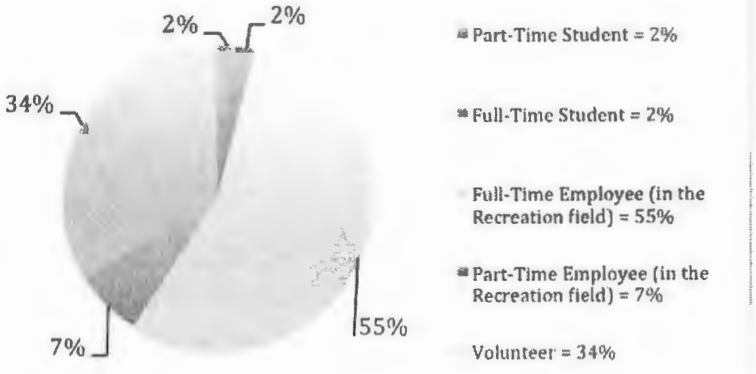

Figure 1: Employment Status of Respondents

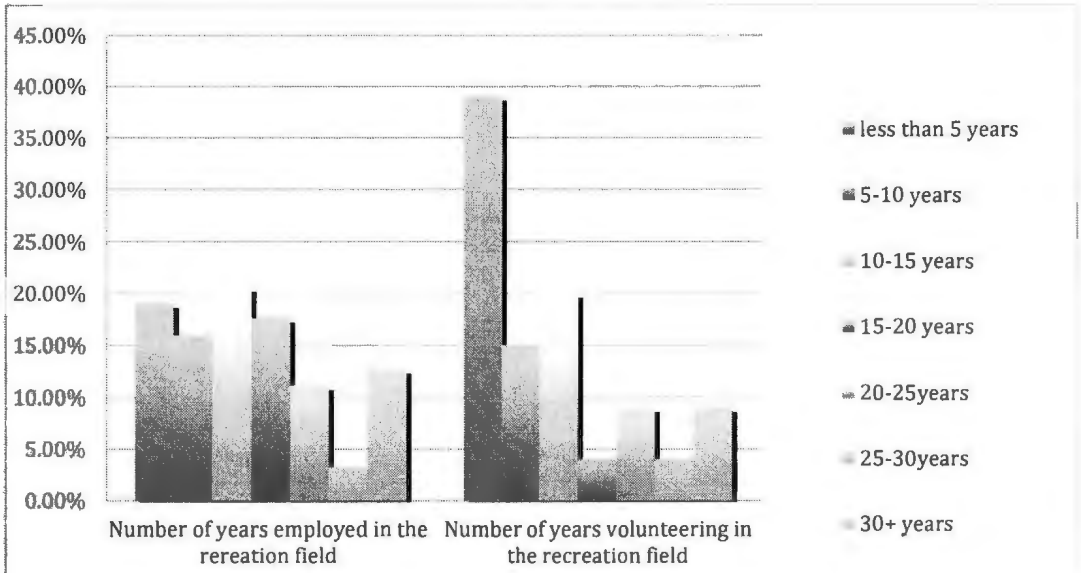

Figure 2: Number of Years Participants been Involved in Recreation Field

4.2 WORK / VOLUNTEER ENVIRONMENTS REPRESENTED

The respondents represented a wide range of work / volunteer environments. As depicted in Figure 3, the highest percentage of participants (19.6%) are from a city and are likely to be employed, while the second highest are from rural communities – population under 1000 (17.4%) and are likely to be volunteers. Overall, most of the respondents (80.4%) represent a municipal environment: city, large town (population 5000+), medium town (population 3000-4999), small town (population 1000-2999), and rural community (population under 1000). Some of the environments that fell into the "other" category" include: aquatic center, arena manager, non-government agencies, government, military community, not-for profit, outdoor youth program, etc.

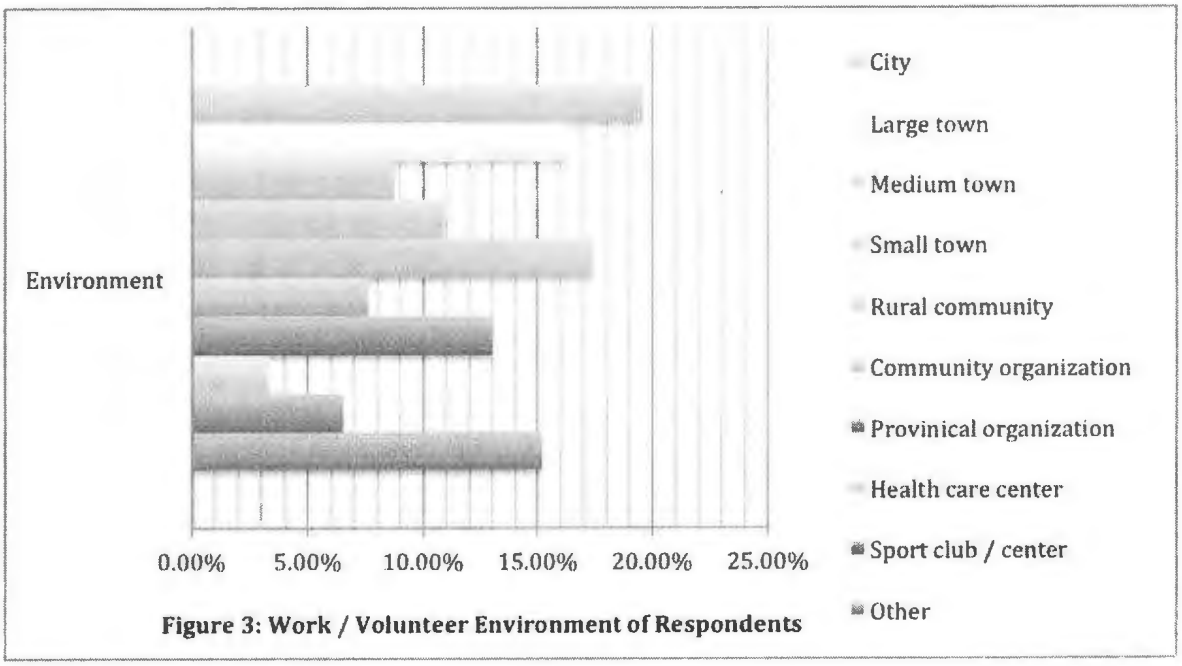

Figure 3: Work / Volunteer Environment of Respondents

4.3 EDUCATION / TRAINING

The respondents also reported their level of education / training. Twenty percent (19.6%) indicated a high school diploma as their highest level of education. Among those providers who had a Bachelor degree (58.7%) only 20.7% have a Bachelor degree in Recreation while the majority (38.0%) has a Bachelor degree in a different program such as Business, Art and Education. The similar pattern was found among providers who have a college diploma: only 15.2% have a diploma in community recreation while 19.6% have a diploma in a different program such as Architectural Engineering and Business. Thus among the respondents there are a higher percentage of individuals with non-recreation education. This result may be due to the fact that there was a high representation of volunteers who completed the survey (i.e., whose professions might not be in recreation). However, the result makes one question if there is a lack of support in the profession to hire recreation specialists.

4.4 OFFICIAL TITLES

The respondents were asked to provide their official job / volunteer titles to help give an indication of the type of position they held within the community / organization they represented. The titles were grouped into one of five categories; each category had a variety of different job titles and variations (see Table 2). Some titles are much more explanatory and focused than others.

Table 2: Official Titles of Respondents

Category	Sample of Titles	Percentage of Respondents
Recreation Practitioner / Leader	Arena / Aquatic Manager Director of Parks / Recreation and Tourism Fitness Leader Supervisory of Recreation and Healthy Living Youth Center Coordinator	42.4%
Volunteer	Chairperson President Secretary / Treasurer	20.7%
Management / Business	Executive Director Financial Officer General Manager	18.5%
Municipal Employee / Councilor	Deputy Mayor Town Clerk Town Manager	5.4%
Other	Elementary Teacher Playground Designer/Consultant, Estimator Sales & Design Consultant	13.0%

4.5 FACILITY RESPONSIBILITY

Respondents were asked if they were directly responsible for a facility and if so to identify the type(s) of facility(ies) they oversaw (see Table 3). Forty-five percent (44.6%)

of the respondents identified that they are responsible for a facility. The number one and two ranked facilities that were identified are both outdoor facilities: Outdoor Sport Fields (64.1%) and Playgrounds (61.5%). The third and fourth ranked responses were the indoor facilities with the highest percentages: Community Center/ Youth Center (46.2%) and Indoor Swimming Pool (35.9%). Among the 132 respondents, 56.8% of them are responsible for outdoor facilities. No individuals were responsible for Indoor Sport Fields. There is only one indoor sport field in the province; thus, no recreation professionals from this facility responded to the survey.

Table 3: Facilities Respondents Oversee

Facility	**Percentage**
Outdoor Sport Fields	64.1%
Playgrounds	61.5%
Community Center / Youth Center	46.2%
Indoor Swimming Pool	35.9%
Hiking / Walking Trails	28.2%
Gymnasium	25.6%
Indoor Arena	25.6%
Other	20.5%
Outdoor Arena	10.3%
Outdoor Swimming Pool	7.7%
Boating Facility (canoe, kayak, etc.)	7.7%
Bowling Alley	5.1%
Indoor Sports Fields	0.0%

The respondents were also asked if they used facilities operated by another organization for their programs and services. It was interesting that 60.0% of the respondents identified they do use other organizations facilities for their programs and services. Over half of these respondents (58.3%) stated that their programs and services are regularly housed in another organizations facility. Seventy-five percent of individuals

who utilize other organizations' facilities have a partnership for the usage and 60.0% receive the facility space for free or at a reduced price.

5.0 IDENTIFYING AND DESCRIBING PROFESSIONAL ISSUES & CHALLENGES

5.1 RESPONDENTS SELF-IDENTIFIED ISSUES & CHALLENGES

Respondents were asked to identify the top five issues they are challenged with on a regular basis in terms of providing recreation services and programs and , as well as managing facilities. The responses were categorized into the 10 issues/challenges that were identified the literature review. Those that did not fit were placed in the category named other (see Figure 4). The category "other" consists of challenges that are specific to NL. It is interesting to note how the responses decreased: 78 respondents provided a response for their top issue; 75 gave an answer for issue two; 68 provided a third issue; 47 respondents gave an answer for issue 4; and only 38 individuals provided a fifth issue. This suggests that respondents were mostly interested in their top issues or had difficulty identifying additional issues.

The top three issues/challenges that were self-identified by the respondents were the same three identified in the literature: budget, staffing and facilities. Issues and Challenges categorized as "other" were also very high (see Table 4). Each of these categories represented a variety of issues / challenges; some examples are presented in Table 5.

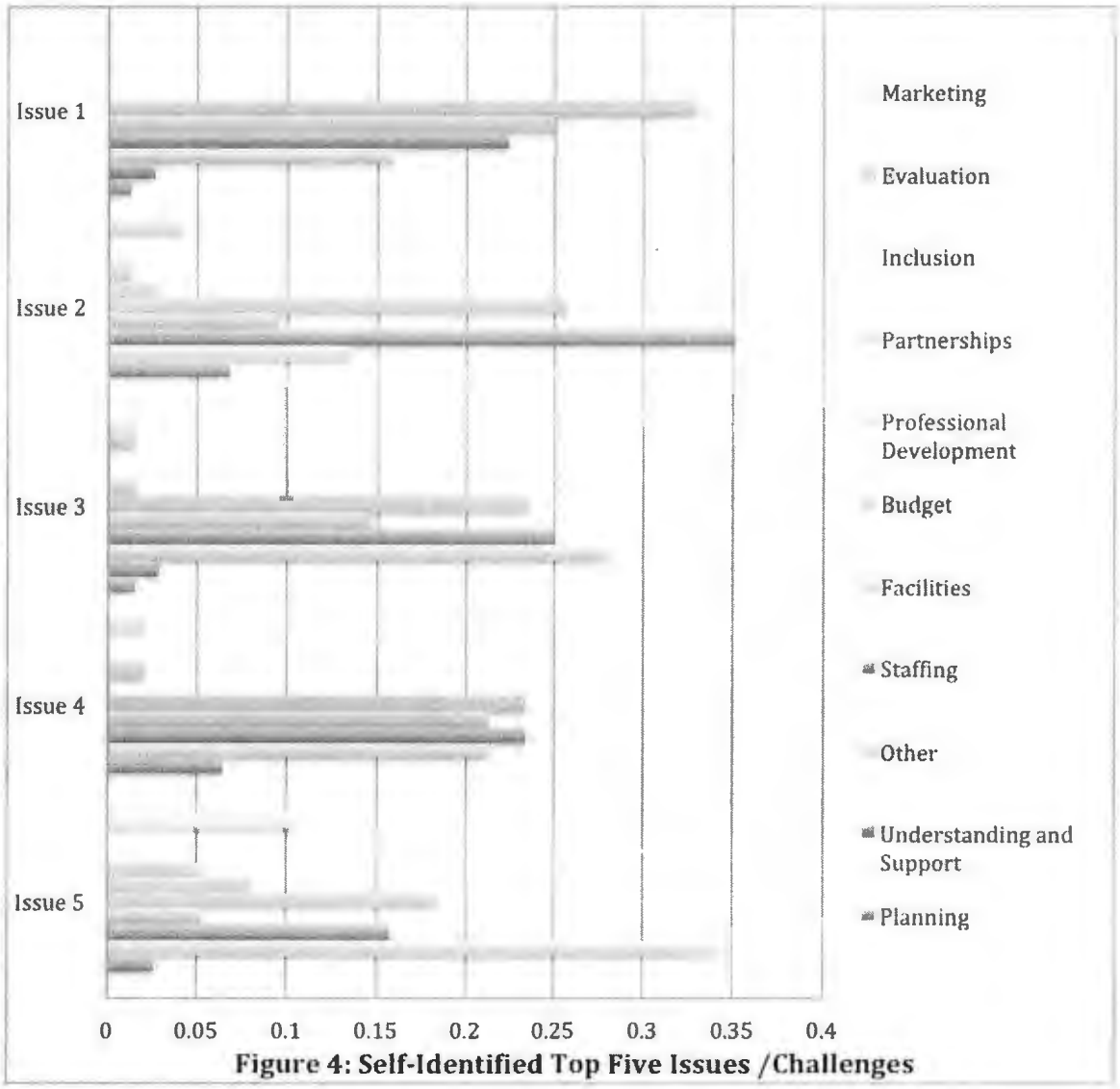

Figure 4: Self-Identified Top Five Issues /Challenges

Table 4: Percentage of Self-identified Issues and Challenges by Category

Category	Issue1	Issue2	Issue3	Issue4	Issue5
Budget	32.9%	25.7%	23.5%	23.4%	18.4%
Staffing	22.4%	35.1%	25.0%	23.4%	15.8%
Facilities	25.0%	9.5%	14.7%	21.3%	5.3%
Other	15.8%	13.5%	27.9%	21.3%	34.2%

Table 5: Examples of Self-Identified Issues / Challenges Samples

Category	Responses
Budget	- Lack of funding and resources - Not having enough funds for programs - Operating grant - Cost of utilities - Finding the different grants that are available to our recreation organization
Staffing	- Younger people, most don't want to work - Volunteer Recruitment / getting harder each year to find quality volunteers - Staffing… Lifeguards needing to be 17 - Retaining Trained Staff - Staff Turnaround - No paid staff - Too much work for one staff
Facilities	- Our facilities are old and in need of repair - Facility upgrades - Aging infrastructure - Lack of facilities - Scheduling programs / Finding space in our facilities
Other	- Meeting needs of all children - Transportation - Area mostly seniors - Customer expectations sometimes unrealistic - Small population - Weather

5.2 RANKING OF ISSUES & CHALLENGES

The respondents were asked to rank the importance of the 10 issues/challenges identified in the literature review. For each issue, respondents rated the issue on a 5-point scale (1 = low importance; 5 = high importance) in terms of importance. An issue viewed as very challenging (limiting the programs and services offered by the organization or community) respondents rated the issues as a "5"; while if the issue was somewhat limiting then respondents rated the issue as 1 to 4 depending on the perceived severity of the issue. If an issue was not a challenge respondents selected "not applicable." Similarly,

respondents were also asked to rate if they have the resources needed to address the issues and challenges (1 = low/no; 5 = high/yes).

Table 6: Issues / Challenges Rankings

	Importance of the issue / challenge [a]		Resources to address the issue / challenge [b]	
Issue / Challenge	Mean	Standard Deviation	Mean	Standard Deviation
Staffing	3.9	1.29	2.7	1.25
Budget	3.9	1.19	3.0	1.35
Facilities	3.6	1.36	3.0	1.25
Understanding & Support	3.4	1.31	3.2	1.13
Marketing	3.3	1.33	3.0	1.21
Inclusion	3.3	1.16	3.0	1.11
Partnerships	3.3	1.19	3.3	1.09
Professional Development	3.3	1.42	3.4	1.12
Planning	3.2	1.28	3.3	1.19
Evaluation	3.2	1.17	3.0	1.10

[a] 1 = low importance; 5 = high importance
[b] 1 = low/no; 5 = high/yes

As identified in the previous results, staffing, budget and facilities remained the top issues/challenges facing recreation providers in NL (see Table 6). This table also clearly identifies that recreation providers do not have the resources they need to overcome the largest issues/challenges they face. According to these statistics the issues/challenges that they are most equipped with resources to address are: professional development, planning, and partnerships. These three issues and challenges ranked 8th, 9th, and 7th in importance. Thus there appears to be fewer resources for the most challenging issues while providers indicate a greater amount of resources for issues that are not ranked as most important.

5.3 DESCRIBING THE ISSUE & CHALLENGE

To gain a better understanding of each issue / challenge and how it affects recreation providers' work, services and programs. The survey respondents were asked to complete a series of questions for each of the 10 issues and challenges. For each of these questions respondents were asked to rate each statement on a 5-point scale (1 = low/no; 5 = high/yes).

5.3.1. Budget:

Seventy participants answered the survey questions about budget. It is evident that recreation providers in NL have a limited budget. The majority of respondents indicated that they did not have a sufficient budget for each program or service delivered (average = 2.9). The majority of respondents felt that reviewing the operating costs of their facilities/programs/services would not have a positive effect on issues related to budget; they feel that increasing fees would not increase revenue as it may increase barriers. Recreation providers need more grant funding, as 22.9% stated they do not see increasing fees or changing operations to have a positive benefit to their budget. Ninety-five percent of respondents stated that their organization would benefit from additional grant funding. Considering that respondents indicated that they had the resources (staff, skills, etc.) to seek the additional funding (average = 3.5) the issue may be that there isn't enough grants to apply for or the grant funding amounts are not large enough.

Budget as an issue and challenge was discussed during the facilitated breakout session and reinforced the findings of the survey. The participants stated that budget is a

major issue as with no money that can't provide programs or services. Many of the programs and services they provided rely on grants and sometimes the grants don't provide a sufficient amount of funding to do an efficient job. Providers felt that the grant applications can be difficult to complete and often have unreasonable deadlines for submission. Grant funding is dependent on municipal council; the connection between this issue of budget with the issue of understanding and support is discussed later in this paper. It is difficult to compete for dollars when competing against essential services and recreation is not seen as one. Providers indicated that in order to operate with a limited budget they need to do better long term and short term planning; this links to the issue of planning. To be successful in acquiring additional funding, they need access to more professionals (e.g. recreation practitioners, council leaders, government consultants) and access to other financial supports.

5.3.2. Staffing:

Seventy participants answered the staffing section of the survey. Recreation providers rated the skills (recreation competences needed to review/oversee the organization) of their board of directors/town as being above average (average = 3.5). Respondents (73.1%) indicated that they do not have the number of staff or volunteers to efficiently deliver quality programs and services. Sixty-seven percent of providers felt that new/potential workers of their organization had average or lower skills required to do their job efficiently without additional training. Survey respondents indicated that their organization offers employees regular training (average = 3.6). In contrast the facilitated

breakout session discussion suggested that recreation organizations and commissions in NL have limited skilled workers (staff and volunteers). It is unclear if there are enough workers to ensure quality programs and services and they could benefit from additional education and training.

Respondents felt that the staff in their organization was satisfied in their current positions. The majority (52.9% rated the statement as 3 or higher) stated that their organization experiences frequent staff turnover. These respondents were asked to comment on why they felt their organization has been struggling with securing long-term staff (see Table 7). The majority of the responses commented on young staff (students) was the reason they have high staff turnover. Young staff work with the organization for only short periods and then they move on to either a different career, seek post-secondary education or move out of town. Other comments suggested that low wages and entry level positions were the reason staff only stayed for short periods. It was also mentioned that it is hard to retain volunteers, as people seem to be busier.

Table 7: Sample of Comments on Reasons for High Staff Turnover

Lack of competitive wages for the amount of work being done and responsibility that the job carries.
Compensation vs duties and role. Staffing turnover is a direct reflection of an organization that has not changed the way they do business with the change in staffing expectations.
People are just busy with their full time jobs or their family life to volunteer more time with us.
The bulk of our staff are students who leave the community to further their education.
Inability to offer further recreational supports within the town; also there are no incentives for volunteers which today is a big motivator if you wish to get new volunteers involved.

The facilitated breakout session stated that staffing challenges has a strong connection to the issue of budget. Providers are highly dependent on grants to hire

additional staff, especially seasonal staff, and they struggle due to the shortage of grants available and the short timeline from when the grant is released to when the application are due. Also, they struggle for municipal budget dollars; again putting emphasis on the importance of having understanding and support. Many have challenges with getting workers due to population size, students leaving the area, and competition with other groups / organizations (e.g., fast food businesses). These factors also contribute to the challenge of training their staff, especially seasonal staff. Limited grant funds don't allow for a sufficient amount of time to train their staff before programs start, and if staff are trained then they have to shorten their programs. Also, they have the repetitive challenge with turnover; they have to continuously retrain new staff. Participants of the facilitated breakout suggest they need support from various sources to assist with this issue / challenge (see Table 8).

Table 8: Staffing Supports

Who:	**Why:**
Canadian Tire Jump Start	- To help with cost
School Board	- Provide in-school training to students, maybe as part of curriculum to help make sure they are somewhat qualified and trained before hiring for summer program starts.
Provincial Government	- To assist with funding to hire staff
Community Volunteers	- Deliver the services
City / town	- Allocation of the money and support recreation
Federal Government	- Need to get increase percentage from tax payers money to be able to provide better opportunities and this will trickle down to provincial level, etc.

5.3.3. Facilities:

Sixty-five participants answered the survey questions about facilities. Recreation providers in NL have limited facilities to house their programs and services (average = 2.8). The facilities that are available have adequate space (average = 3.23) and are accessible for persons with disabilities (average = 4.0). The majority of respondents felt that the location of the facilities was accessible to everyone in the community (average = 4.0).

Facilitated breakout session participants suggested that there is a lack of facilities (especially in rural areas) and the facilities they have are aging. Due to the minimal amount of facilities they find it difficult to schedule programs and events due to the limited space available. Many would like to create partnerships to use other facilities in their community (such as schools) for recreation, while others would like to create partnerships with other communities and towns to build/share regional facilities. The sharing of facilities thus connects to the issue to the issue of partnerships. Budget is a predominant factor within the challenge of facilities; the high cost to build new facilities and the funds required for maintenance and upkeep. There are no major funding grants for building new infrastructure and very few grants with the province of NL that provide support for facilities (e.g. facility operating costs or maintenance).

5.3.4. Inclusion:

Sixty-five participants answered the survey questions about inclusion. It is evident that recreation providers in NL could use more support to improve the inclusiveness of

their recreation programs and services. They have self-rated the programs and services they provide to be at or below average in terms of inclusiveness (55.7%); meaning they know that there is more that could be done to reach out to potential participants in the community. Providers felt that their organization is able to meet the needs of their communities from all income brackets (i.e., low, middle and high income; average = 3.6). Respondents stated that they are slightly below average (average = 2.9) in terms of the equipment to meet all the needs of their community. Budget was identified as a barrier to the ability to be more inclusive (89.4%) and respondents felt that additional training may positively benefit their organization's ability to be inclusive (average = 4.2). Thus, an insufficient budget maybe the barrier to additional staff training or the need for additional training may suggest that there aren't enough training opportunities available on inclusiveness.

The facilitated breakout session participants stated that they need more education on inclusiveness; education not only for their staff but also for the public, parents and their participants. Unfortunately transportation is a major barrier in inclusiveness; they cannot get the participants to the programs or the facilities. Budget is a major factor within this issue as training fees, transportation, and facility and equipment upgrading and modification can be very costly.

5.3.5. Planning:

Sixty-five participants answered the survey questions about planning. Recreation providers in NL are only partly planning and evaluating to the extent they feel they

should / could be. Respondents highly rated their organizations' ability to plan effectively (average = 3.8). They felt that they had the time to plan effectively (average = 3.4) and that their organizations have the knowledge and skills to do the planning they require (average = 3.7). The majority of respondents felt that their organization is effectively evaluating programs and services (average = 3.3).

5.3.6. Understanding and Support:

Sixty-five participants answered the survey questions about planning. Recreation providers in NL feel that they are supported by their board of directors / town council (average = 3.9). Similarly, respondents rated an above average amount of support for new recreation programs and services from participants / community (average = 3.8). There is a need to increase awareness of the benefits of recreation considering that 81.7% rated their organization's ability to market the benefits of recreation to the community as low. As previously identified understanding and support is an overarching challenge to many of the other issues.

5.3.7. Marketing:

Sixty-four participants answered the survey questions about marketing. Recreation providers in NL are struggling to market their programs and services to the public. Over half of respondents (71%) felt that additional marketing could positively affect their organization's programs and services. They have identified that they have a need for additional support with marketing. Seven-one percent of respondents felt that

their organization had the budget to effectively communicate to the public about their programs and services; 35.9% stated that marketing is not budgeted for programs and services. Half of respondents stated that their organization does not have marketing policies and 37% stated that marketing is not built into their organization's program plan whatsoever. Recreation providers felt that their employees and volunteers do have the training and skills to effectively communicate to public about programs and services (average = 3.6). They could use additional training to improve marketing skills and to learn how to create a marketing plan.

Respondents were asked to identify all of the marketing venues regularly used (see Figure 5). Most respondents use the local media outlets in their area, relying heavily on communication via posters/ flyers. Other marketing venues had a large percentage of respondents (46.9%). Respondents were asked to specify these marketing venues which included the local community list serve / email, school bulletins / community guides / newsletters, bulletin boards, community digital sign / display TV's, website and social media (facebook, twitter and blogs).

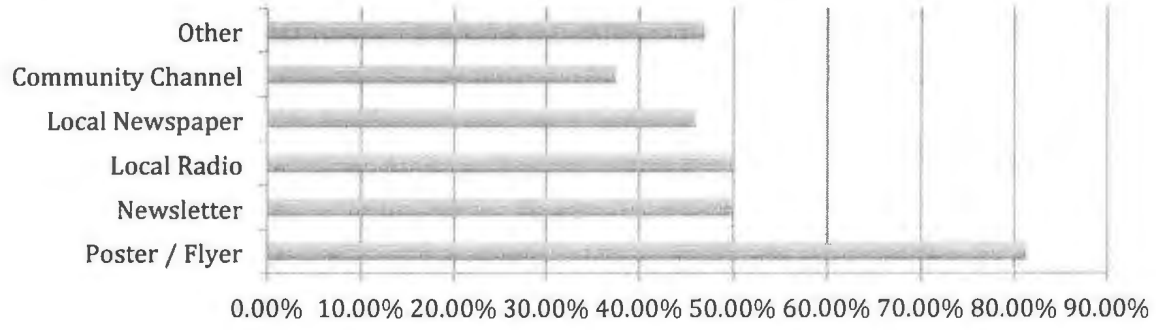

Figure 5: Marketing Venues

The facilitated breakout session stated that they are struggling to get their message out through traditional means; they lack expertise to reach their residents through new media communications. Many have to rely on volunteers/students in the community to spread the message, especially via social media. Some stated that it is not just technical outlets that they lack, they would also benefit from signage and community events calendars. These marketing challenges require funding, access to grants, partnerships with community organizations, and support from council. Table 9 presents the supports suggested by the participants of the facilitated breakout session in order to assist with the marketing challenges.

Table 9: Marketing Supports

Who:	**Why:**
Local private business	- Network opportunity - Financial support
Provincial / Municipal support	- Funding to assist committees
Government	- Expertise on how to fill out grants to get funding to market
School System	- Look at students who could help develop a social media plan
Regional Community Station	- Help us get the message

5.3.8. Partnerships:

Sixty-four participants answered the survey questions about partnerships. Recreation providers in NL partner with other agencies regularly (81.7%) to deliver programs and services. They self reported that their partnerships are positive (average = 3.6). Over half of respondents indicated that they never (28.1%) evaluated or were not

sure if they evaluated (25.0%) their partner relationships. Only 20.3% of respondents indicated that they evaluated their partnerships on a yearly basis.

5.3.9. Evaluation:

Sixty-three participants answered the survey questions about evaluation. Recreation providers in NL need to do more evaluation. Only 35% of respondents stated that they evaluate their programs and services on a yearly basis. Sixty-six percent of providers indicated that their organization has the time to regularly evaluate; staff, programs, services, facilities, etc. They felt that employees and volunteers had average training and skills to effectively do evaluations (average = 3.0). Limited or no financial resources were reported as affecting their ability to evaluate. Thus, recreation providers have self-reported that due to lack of time, evaluative skills, and financial resources they are unable to effectively evaluate the programs and services they offer their community area. It should be noted that under the issue of planning the majority of respondents felt that their organization is effectively evaluating programs and services. Therefore, respondents appear to have provided conflicting results; they rated their organizations' planning for evaluation highly but did not report the same for their evaluative practices.

5.3.10. Professional Development:

Sixty-two participants answered the survey questions about professional development. Figure 6 illustrates respondents' frequency in attending professional development opportunities. The majority of respondents indicated that they had professional development opportunities; 20% stated that they were never able to participate in professional development. While some providers are able to frequently avail of professional development opportunities, 20% of respondents stated that they attended one opportunity per year. Respondents identified the types of professional development they take part in (see Table 10).

Figure 6: Frequency of Professional Development Opportunities

The majority (69.2%) respondents had the staff to support their time away in order to take part in professional development opportunities. Respondents were asked to rate five barriers (1 = largest barrier; 5 = smallest barrier) to attending training opportunities. Support from the board/council was rated as the top barrier to professional development, followed by staff support (i.e., having staff available to cover work while one is away)

and time away from the office. Funding to attend training opportunities was not rated highly has a barrier. Thus, recreation providers in NL want to take part in professional development to further their knowledge and skills, but they lack the resources and support to be able to attend as regularly as they may want or need.

Table 10: Professional Development Opportunities of Respondents

Categories	**Examples**
Continuing Education	Recreation Professional Management Certificate Program
Provincial / National Conferences and meetings	Recreation NL AGM and Conference
Facility Education	Facility Planning Operations
Leadership	HIGH FIVE®
Regional workshops and meeting	Recreation NL seminars
Certifications	First Aid
Informative workshops	Aquatic forums
Management Courses	Management training
Skill Development Workshops	Social Media sessions Facilitator courses
Volunteer sessions	Volunteer recruitment & retention

6.0 DISCUSSION & RECOMMENDATIONS

As previously stated the purpose of this applied project is to a) identify issues and challenges faced by recreation providers; b) determine the importance of these issues and challenges; and c) discuss and highlight recommendations that could help overcome these issues and challenges in the field of recreation. Recreation providers in NL face regular issues that challenges them as they try to provide positive recreational opportunities to the people in their community. The survey results identified these issues and challenges (see Table 11). Each of these 11 issues / challenges will be discussed individually, looking at the factors of each and highlighting recommendations

Table 11: Recreation Providers Issue/Challenges Ranked Greatest to Least

#1	Staffing
#2	Budget
#3	Facilities
#4	Understanding & Support
#5	Marketing
#6	Inclusion
#7	Partnerships
#8	Professional Development
#9	Planning
#10	Evaluation
#11	Other – NL Specific

6.1 ISSUE 1 – STAFFING

For this project staffing refers to both paid and volunteer staff. Staff personnel assist recreation organizations to prepare and deliver their programs and services. Job

duties can include a variety of responsibilities and titles evident in Table 2: Official Titles of Respondents.

From the empirical data collected for this project, it is clear that there is a need for more full time paid recreation practitioners in the recreation sector. It was indicated that practitioners are essential to supporting recreation in a well-structured recreation organization; as well their expertise is valuable to the volunteers in the field. Having a full time staff person(s) dedicated to recreation gives the community or group/organization support to apply for more funding, and offer more programs and services. Part time / seasonal paid staff are also very valuable to organizations, as organizations would not be able to deliver the amount, variety or quality of recreation programs and services without them. Many organizations rely heavily on volunteer support to deliver their programs and events and to sit on the organization's Board of Directors.

With this much reliance on staff it is alarming that the main challenge of staffing is keeping and sustaining paid staff and volunteers. From my experiences I have heard many paid practitioners and volunteer express that they are overworked; the expectations of the recreation department or commission are too high for the amount of human resources. This is especially true for those providers within small communities / areas, they have too much work and responsibility for small/one person departments and/or volunteer groups. Providers are also concerned about the amount of additional work being added to their responsibilities such as special events and assisting additional service groups. Therefore the issue of staffing is heavily tied to the challenge of budget, as well as understanding and support from administration. It is hard to sustain paid staff if there is limited funding to hire additional support staff (not enough positions), and uncompetitive

wages to attract potential staff and/or secure them long term. Providers expressed that staff turnover is very challenging; looking for new staff each year can be difficult and the constant need for staff training and orientations is expensive and time consuming. Decision makers need to understand the workload and importance of the recreation practitioner to ensure that the wages are adequate for the responsibilities of the position.

Retaining volunteers can be challenging. Recreation providers expressed, a decrease in the amount of people that gain a sense of fulfillment by giving back to the community. This places those few people volunteering at risk of becoming burnt out due to over commitment with little or no incentives to award their volunteerism. Lack of volunteers limits the amount and length of time volunteer dependent organizations can offer programs and services. The amount of time asked of volunteers to commit can also be a deterrent. More volunteers may take part if the responsibilities and time commitment was reduced.

The ability to train staff was another factor highlighted from the survey and facilitated breakout session. With high staff turnover recreation providers continuously have to train new part time / seasonal / volunteer staff, never having the opportunity to build on staff expertise. Training will be discussed more in the professional development section.

Recommendations:

- Create and sustain a provincial funding program to support more full time practitioner positions (full time paid staff).

- Funding programs and grants need to provide adequate supports (wages, resources, consultants, advisory committee, etc.)
- Increase grant funding to recreation organizations to create more support positions and make wages more competitive.
- More educational information for elected personnel outlining the importance of recreation, its benefits and operations. Organizations need members on their board of directors and council who understand the long-term vision of the organization as well as the daily operations of its employees.
- Educational institutions need to work with recreation organizations and practitioners to identify the skills needed for students to be successful in the work force. This can help reduce some of the upfront training cost for organizations.
- Create volunteer publicity campaign to promote the importance of volunteering. This will encourage new people to volunteer and provide those looking for volunteers the tools to recruit and incentives (honorariums) and recognition (awards and/or prizes) for volunteers donated time.

6.2 ISSUE 2 – BUDGET

Recreation providers are asked to provide and deliver many programs and services, but they can only be as efficient or provide as much as the budget will allow. Therefore budget is the main determining factor of all structured recreational opportunities and spaces. Budget is a challenge within each of the other recreation

providers' issues. For example, previously mentioned budget is one of the main reasons why staffing is such a high priority issue.

Budget is an issue primarily because there is a limited amount of core funding provided for recreation from funding providers (i.e., provincial and municipal governments). With many recreation organizations competing for the same money, it is not surprising to see that organizations are not getting the adequate amount of funding they require. Therefore recreation organizations and commissions need to seek funding from other (non-traditional) sources, such as, the wellness sector and funding competitions (e.g., Kraft Hockeyville). Securing alternative funding can be time consuming and difficult.

Writing the grant applications (or following application requirements) is also a big challenge; finding, and completing grants requires skill and time. There was concern expressed about the application submission and awarding process of grants from the facilitated breakout session. Many practitioners have expressed frustration regarding the very short timelines given for the submission of grant applications. The timing from when the grant is announced (or when applications are made available) doesn't give them the time needed to fill out and prepare the application as planned and as detailed as they would like, especially if letters of support from partners or approval from council are required. Providers sometimes miss out on grant opportunities if they are not regularly checking for them or are unable to fulfill the entire requirements in the time period. Also many times it takes too long to receive the actual funding, thus providers are unable to properly plan and sometimes have to change plans based on when the funding is received.

Organizations and commissions need core funding to operate and run programs. Unfortunately providers in this province expressed that they don't have the core funding they require and are dependent on grant funding. Each year organizations and commissions have to (re)submit for funding. Many grants available are for programs only or pilot projects. While program only funding is good for building programs, it doesn't give the provider operational longevity. Providers expressed in their survey responses that pilot project grants can be unsustainable therefore making it hard to build momentum in the project.

The other issue that is linked strongly to budget is understanding and support. It was also expressed in the facilitated breakout session that many of the decision makers don't understand the role or the long-term goals of recreation in their community, therefore making it difficult to assist with effective budget allocation. The facilitated breakout session felt that recreation organizations and commissions need to do better short and long term planning as well as have access to more professionals and other financial supports.

Recommendations:

- There is a need to increase funding for recreation at all funding levels, especially provincial and municipal governments.
- Create awareness and educational sessions to help funders get a better understanding of the cost of recreation.

- Grant providers need to work more closely with recreation practitioners and volunteers. They need to understand their needs, planning process and workload so that grants can be completed and used more effectively.
- Create / offer grant seeking and writing training sessions, that provide the skills to make looking and filling out grants applications easier and less time consuming.
- Provincial Grant programs should follow the work of providers and provide yearly support without requiring application submissions each year. This would give the provider a guarantee of core funding.

6.3 ISSUE 3 - FACILITIES

A recreation facility can range from an arena, to a swimming pool, to a bowling alley, to a gymnasium, or a multi-purpose structure. From the survey results the most common recreation facilities in NL are outdoor sports fields, playgrounds and community / youth centers. The purpose of a facility is to help meet the needs of the community by providing a space for recreation opportunities to take place. The results of this study identified a need for; more facilities, upgrades to existing facilities, assistance with maintenance and upkeep, and facility-sharing partnerships. In this section I discuss the main challenges of facilities expressed by NL providers: budget, skilled staff, planning and partnerships.

Budget constraints are a major challenge when trying to offer recreational facilities. A facility can have many benefits including adding additional recreation opportunities to the existing variety within a community, as well as creating more space

for current programs to grow. There is an expressed need for more facilities in the province and upgrades to existing facilities. Survey respondents shared that they don't have facility space to offer their programs; either because their community doesn't have a facility, or the facilities have limited space and thus don't allow them to access space at convenient times. In order to increase facilities there needs to be dedicated funding to build, renovate and maintain facilities. It was expressed through the facilitated breakout session that there isn't enough specific grant funding available that is targeted for facilities, buildings or upkeep. In NL many facility supplies have to come from out of province, and energy costs are quite high. These local factors increase basic facility operating costs. Thus, old facilities with ongoing maintenance issues can be financially draining. An additional budget item is staff; staff plays a large role in creating the environment within the facility and the facility operations: management, program, maintenance, etc. Training and retaining staff for facilities connects to the number one issue outlined by the recreation providers in the province- staffing.

Another factor of building a facility is that it requires much planning to ensure it can be: sustainable, maintained, accessible, inclusive and able to provide the opportunities the community needs now and in the future. This links the challenge of building a new facility to the issue of planning. Planning for a facility requires looking at the current and predicted demographics of the service area throughout the facilities life span. A facility can be built ready to accommodate the current and predicted demographic or it can be built in stages to improve upon and adjust to future needs.

Many organizations currently have partnerships to assist with their facility needs. Others would like to have a partnership, but they struggle with creating them. This

challenge relates to the issue of partnerships. Recreation providers struggle to create and build partnerships with facilities in their community because the ones with the facilities don't consider themselves a community facility and don't understand the positive benefits that partnerships could bring. There is a need for all facilities to be open to the community, to reduce cost and create more/new opportunities for everyone. Survey responses suggested that community use of schools would help greatly with the facility challenge especially in small communities / regions.

Recommendations:

- Create targeted grants to help assist with facility planning, building, maintenance, renovation and staff.
- Provide training sessions for facility building and maintenance. To educate providers and decision makers of all the stages and skills needed in creating and operating a facility.
- Governments need to work with organizations to create community facilities (partnerships). Assist with the creation of policy and procedures, and assist with insurance and risk management needs.

6.4 ISSUE 4 – UNDERSTANDING & SUPPORT OF RECREATION

Recreation is a widely used term used in many situations but unfortunately the field of recreation is not well understood by the general public. Recreation includes a wide variety of opportunities and experiences that can provide many benefits for

participants, however recreation is often misinterpreted for health or sport, as many community health and sport opportunities are offered by or through the community recreation provider. Recreation includes health and sports, but health and sports isn't necessarily recreation.

The recreational opportunities provided by the community recreation department or organizations are programs and services for residents to take part in during their leisure for their enjoyment and to enhance quality of life. Unfortunately recreation is not considered an essential service, and can be overlooked by elected government officials at every level in the budget deliberation especially when; roads, sewer, water treatment and healthcare are competing for the same money. Even as an unessential service recreation is still expected and desired, and the opportunities are expected to be accessible and of high quality. In order to meet these expectations providers need support including: funding, staffing, and facilities. Thus, the issue of understanding and support is an overlying challenge to many other issues discussed throughout this report. Decision makers need to understand recreation in order to be able to support it; and from the survey results recreation providers in NL only feel somewhat supported.

Marketing the recreation programs and services offered by the community can help increase participation. Marketing the benefits of recreation and its ability to increase quality of life to residents can help with gaining support from governments and funders. The issue of marketing, which will be discussed next, is strongly linked to the issue of understanding and support. Associations and organizations that provide assistance to the recreation sector, such as provincial organizations and post-secondary institutions, have a

role to play with promoting the importance of recreation as well. They can assist providers with increasing their voice for support.

Recommendations:

- More public awareness about the importance and benefits of recreation. A provincial campaign needs to be created.
- More education is needed for decisions makers (governments of all levels). They need to understand the role and importance of recreation in the lives of community / provincial residents.
- Provincial associations and institutions need to assist with educating the key stakeholders and the public.
- Providers need a platform to highlight the benefits of the programs and services they provide and showcase it. Celebrating the benefits of the programs and services being offered will help bring value to it.

6.5 ISSUE 5 – MARKETING

Marketing is essential to promote the recreation opportunities being offered to the target market it is intended for. There are many different means to communicate to the public; the challenge is: knowing which is best for the market being targeted, getting the best value for the budget, and how to communicate the information the participant needs to know.

Effective marketing takes skill; providers need support and training on how to market effectively. They need to know how to develop marketing resources that will attract the target market. This requires funding within every program and service plan; a portion of the budget needs to be dedicated for marketing, as marketing resources can be costly to develop and publish. Recreation providers should be aware of all the costs to budget accordingly; therefore marketing is dependent on issues of budgeting, staffing and professional development.

Marketing is an evolving issue, as the means and channels of marketing change with new technology. Providers need to learn and keep up with new technologies (e.g., Facebook and Twitter), while still using the traditional methods, as the consumers are of all ages and may only use / read select media. Recreation providers require funding, access to grants, partnerships with community organizations, and support from council to address marketing challenges.

Recommendations:

- Professional development opportunities for marketing are needed to learn the new technology and how to market to the new technologically savvy generation.
- Grant and funding suppliers need to be aware of the increased cost (more money, more staff, etc.) of marketing and provide more support.

6.6 ISSUE 6 - INCLUSION

Offering inclusive recreation means having the ability to accommodate the needs of each individual as seen appropriate, whether it be assisting with finances, providing accessible facilities, or other personal needs. Each situation should be assessed, as what works for one individual may not work for another. Accessibility is important factor to consider with offering programs and services. Accessibility relates not only to the physical structure of the building (e.g., doorways, ramps, etc.) but also access to and from the location and user fees.

Facilitated breakout session results indicated that transportation within NL is an enormous barrier; participants cannot get to the programs or the facilities. As previously discussed many recreation providers in NL struggle to sustain funding. This makes it difficult for them to keep user fees at affordable rates for everyone and still cover their cost. From the facilitated breakout session, most providers connect participants with subsidy programs such as Canadian Tire Jump Start in order to assist users with fees and cost so they can afford to participate.

Individuals within a community may have other personal needs that they require assistance with in order to participate and enjoy a recreational opportunity to the fullest. An individual may require physical, behavioural or communicative support. This relates back to the issue of staffing, particularly staff training. Organizations need to ensure the leaders have the appropriate skills and knowledge to work with participants.

There are many factors to consider when providing an inclusive environment. Communities are always changing for this reason it is important to conduct a needs assessment on a regular basis and be prepared to assess when a new individual registers. Providing inclusive recreational opportunities may mean providing different requirements for each individual, depending on each situation. Providers need to assess each situation to find what works best, as what works in one situation may not work in another. As identified by the facilitated breakout session discussion there is a great need for more education on the provision of inclusive recreation, not only for their staff but also for the public, parents and their participants. Again, budget is a major factor within this issue as education, transportation, and facility and equipment upgrading and modifications can be very costly.

Recommendations:

- Grants and funding providers need to be aware of the challenge of ensuring inclusion for all. Educational campaigns need to be created to help educate funding providers.

- Funding needs to be provided to recreation providers to assist them with conducting needs assessments. Needs assessments can be an essential tool and can help validate grant-funding usage.
- Increase in grants for facilities to upgrade and modify equipment as well as provide facility staff supports.
- Create professional development opportunities to educate recreation providers about inclusion. Including: how to incorporate participants with special needs into a program and when it is appropriate / required to have separate programs / groups for different ages and abilities.
- Create a provincial communication network to share information on how others handle situations (protocols).
- Create a provincial committee to be the voice, advocate on behalf of the providers and provide educational tools.

6.7 ISSUE 7 – PARTNERSHIPS

Partnerships that combine the strengths and resources of a variety of organizations have been identified as key to providing successful programs. Small communities in NL find it difficult to sustain recreational programs due to small population and lack of resources. Regional partnerships have been beneficial for some areas in NL. Regionalizing services opens opportunities for better programs and services due to shared resources. Partnership activities should facilitate the allocation of key resources toward improving recreation programs and services. Unfortunately different organizations and

partners can have different plans, policies and procedures; these can lead to complications when trying to work together. Also regionalization increases other challenges such as transportation, equal community usage and support.

Once a common goal and relationship between partnering organizations has been established it is important that the relationship is evaluated and reviewed on a regular basis. Failing to do so can cause unnecessary challenges and if left too long before being addressed can complicate the quality of the program or service. The results of this study showed that many providers rarely evaluate their relationships. Could the partnerships be more effective if they were evaluated? Why don't many providers evaluate their partnerships? Is it due to lack of resources or because their not sure how to evaluate partnerships? Lastly, could unevaluated partnerships become negative, therefore discouraging providers to want to try new ones?

Recommendations:

- Create a guiding document, with training supports to help providers create and maintain positive partnerships.
- Create provincial recreation regional policy resources, regional development grants and support for forming regional partnerships to share recreational services.
- Decision makers and funding providers need to encourage and support partnerships, as partnerships can effectively make use of resources available.

6.8 ISSUE 8 – PROFESSIONAL DEVELOPMENT

Professional development is very important for recreation providers to increase and improve their skills, as well as stay on top of current knowledge and trends. The challenge for providers is being able to take the time to attend professional development opportunities due to lack of support staff, as well as the cost associated with registration and travel.

As previously discussed recreation organizations in NL lack staff, therefore it is a large barrier for them for when they want to attend professional development opportunities. This is especially true for volunteers as depending on the travel time to the training location they may need to be away for several days. Rural community isolation can also be a barrier for recreation staff that seeks training being offered in other areas (urban areas of province) or looking to attend national opportunities. Travel expenses, both in and out of province, for training opportunities can be very costly.

Professional development of staff / volunteers should be considered in the budgeting process. Grants are the main source of funding for recreation providers in NL. Therefore the grant suppliers should allow for some of the funding to be used for professional development; having well trained staff / volunteers who are knowledgeable about the most up to date ideas, trends and resources can help benefit the community in the future. Benefits can result in better resources, quality programming, and ease day-to-day operations and save money as trained staff / volunteers are more knowledgeable. Participating in training courses and workshops are also networking and sharing opportunities where participates learn from discussion with each other. For example the

facilitated breakout session participants in this study enjoyed listening to other group members' situations and learned about new opportunities and approaches.

Professional development is an important part of any career - paid or volunteer. Being able to improve existing skills and stay up to date on trends and resources is important in any field of employment. When organizations and departments invest in their staff / volunteers it can improve morale and make the staff feel valued, resulting in higher productivity and a professional work environment. Recreation organizations can benefit greatly by providing or supporting staff / volunteers to participant in training opportunities.

Recommendations:

- Better / more access to professional development funding and bursaries.
- More opportunities, locally to reduce travel expenses and time.
- Increased awareness to the importance and value of professional development from funding suppliers.

6.9 ISSUE 9 – PLANNING

Planning relates to many other issues raised in this report, as having a plan helps guide all aspects of an organization or department. Development of large plans can take time, skills, community cooperation, a budget and an evaluation process. Planning is not achievable without a dedicated budget, support staff, materials and training. Recreation providers in NL say that they have the knowledge and skills required to do their planning,

but many expressed they only partly plan and evaluate to the extent they feel they should / could.

Time is the main barrier to planning. Unfortunately many times the day-to-day operations get in the way of the planning process by either prolonging it or preventing it from starting, as many NL recreation providers do not have the needed staff support. Having a multi-staff department would provide practitioners with the time needed to research and plan.

Once a plan is completed it needs to be put into action and then evaluated. Evaluation ensures that the goals of the plan are being reached. The planning system should be an interactive process that is able to adapt and change as time progresses. Evaluation helps to prepare for and implement recommended changes for the next planning process. Developing a comprehensive process for planning, implementing and evaluating, will help the progression from one stage to another and keep the continuation from one cycle to the next. The results of the survey suggest that recreation providers are not effectively evaluating their planning process and documents.

Program and service participants often assume things are planned, and are mostly interested in what is happening, not how it was planned. However the planning process is important to ensure the best recreational opportunities are being offered. The recreation provider(s) need to be given adequate time, knowledge, skill sets, and funding to ensure effective quality plans and avoid disjointed and reactive planning. Poor planning can be problematic for any organization or department, and create unnecessary issues as organizational and operational challenges can sometimes be linked back to the

organization's strategic plan. As much as planning is a time consuming and ongoing process, it is necessary to overcome struggles and move the organization forward.

Recommendations:

- Grant and funding providers need to give recreation provider adequate time to plan their program(s) and/or service(s) before submissions are due. They need to work with the recreation sector to learn the adequate time needed.
- Planning should be built into the job description of paid staff to ensure they have the time to dedicate to it and are not overworked in other areas.
- Increase awareness to the decision makers as to the steps and time required to plan quality recreational opportunities.
- Create easy to use planning guides and templates.

6.10 ISSUE 10 – EVALUATION

Evaluation is essential in order to meet the needs of current and potential recreation participants and to improve programs and services, as well as be used to leverage additional funds. Evaluations are the best way to get the answers and results of how successful a recreation organization is at meeting the needs of the community. The results of the survey found that recreation providers are not evaluating their programs and services according to best practices.

Municipal recreation departments and commissions need to be concerned about quality of life and service to their residents. They must be actively engaged in identifying

and assessing needs and then utilizing this information to their full potential. Being able to communicate to the community how the department has found and fulfilled gaps will help participants see value in the opportunities being offered. Without regular evaluations and needs assessments providers cannot ensure that they are meeting the needs of the community. Thus, if providers are conducting evaluations they do not know if they could be using the funds and resources they have more effectively, to deliver the programs and services that may have a better benefit to their community residents. In order to do evaluation effectively providers need the tools and support. Recreation providers of NL expressed in the facilitated breakout session that due to lack of time, evaluative skills, and financial resources they are unable to evaluate the programs and services they offer their community area.

Recommendations:

- Decision makers need educational session to be made aware of the importance and challenges of evaluation.
- Grants and funding suppliers need to provide resources (funding and staffing) to assist with evaluation and make it a requirement.
- Increase offerings and access to professional development opportunities to increase leader's evaluative skills.

6.11 NL SPECIFIC CHALLENGES

The survey respondents identified issues and challenges that are specific to the province of NL. These challenges include: population size, regional services, aging population, public interest, community isolation, transportation, local training opportunities, high cost, lack of qualified staff and instructors, unrealistic expectations from local groups, lack of public education on the benefits of recreation, and weather.

As previously discussed, small communities find it challenging to offer programs and services due to low registration numbers, especially for age specific programs or if they don't have access to the resources they need. The demographics of NL are changing and many communities have an aging population with a high percentage of older adults. Therefore many recreation providers are finding they need to change traditional programming. Providers expressed that they struggle to gain community interest; they find it difficult to motivate inactive residents to become active, while others are involved in too many activities and are over-scheduled.

Some communities, especially small communities, have the added barrier(s) of isolation and/or their community area is spread over a large geographic area. Both these challenges make transportation a major barrier. It is very costly for isolated communities to provide field-trips or tournaments for their participants, which limits the program options. Providers whose participants are spread over a large area also have transportation issues. Their participants may not be able to get to the program facility, and providing busing for school age children, seniors or low-income families may be unavailable or too expensive. The cost of travel within and out of NL also has an effect on the cost of

supplies and equipment. The increasing cost of fuel, electricity, propane, etc., also both increase the cost of operation.

As identified staffing is a major challenge for recreation providers in NL. A need for specialized instructors, such as fitness instructors, sport coaches and lifeguards, can be especially difficult for providers to hire. Providers in the aquatic sector have expressed an added challenge for qualified lifeguards because of the age requirement of the NL provincial public pool regulations.

Providers also expressed that they feel overwhelmed, as they try to please public expectations and the demands from other local groups. The definition of recreation is very broad. Because it is so broad many items and projects get handed to recreation providers at the community level such as special events, health opportunities, sporting opportunities. This is especially true in smaller areas and it becomes too much work for one department or commission.

Lastly, the weather in NL can be challenging for recreation providers. Recreation providers in NL have to deal with the unpleasant weather and environmental factors such as: rain, cold and uncomfortable amounts flies. Although these factors are uncontrollable they do create real challenges and limits the amount of activities that can be offered during programs.

Recommendations:

- Create resources and training opportunities to increase knowledge of programming for older adults, as well as programming for small populations.
- Increase or create new grants for older adult programming.

- Create resources and training opportunities to increase knowledge for physical activity programming for all ages.
- Create provincial awareness campaign to increase public education of: recreation, physical activity and the work of community recreation providers.
- Create or increase grant funding for transportation cost; participant transportation, outings, and training.
- Create core-funding grants, to assist with the increase costs of operation.
- Provincial government to work with recreation providers to overcome staff specific challenges in the aquatic sector.
- Create resources and training to increase knowledge of programming in limited spaces and planning for unpleasant weather.

6.12 SUMMARY

Each of the issues discussed creates challenging barriers for recreation providers in NL. This report has stressed the fact that all of the issues and challenges impact each other: with staffing, budget, facilities, and understanding and support having the most overlap. The key concern is how to improve and overcome these issues and challenges that stand in the way of providers being able to provide the programs and service needed in the community that benefit the residents quality of life. The participants of the facilitated breakout session were also asked to list the resources needed to overcome the issue, and whom they would need support from to over come the issue. The responses to

these questions clearly showed that; funding, increase staff, educational resources for decision makers and professional development would significantly improve the challenges and issues. Recreation providers look to RNL and the provincial government as the lead supporters for assistance and to provide these resources, as well as the municipality, funding providers and other provincial associations.

With all the negativity that is associated with issues and challenges it is important to point out that there are some things that the providers recognized that are currently supported in the recreation field within NL:

- Recreation NL provides answers to their questions, provides networking opportunities and access to information.
- Attention to senior's recreation needs have increased.
- The community is supporting and demanding recreation, which means they must be buying into recreation and its values.
- Support from local community groups such as, Community Youth Network.

The response to the survey and facilitated breakout session of this report shows that recreation providers in NL want to be heard and also want to be engaged in terms of finding solutions to their issues and challenges. I recommend that an evaluation of this nature be conducted every 3 – 5 years to tract the improvements and changes, as well as any new or growing issues of the recreation sector in NL.

7.0 CONCLUSION

Recreation providers in NL offer a variety of opportunities for individuals to participate in during their leisure time and to help participants experience enjoyment and live healthier from the benefits they gain through their recreation experiences. Unfortunately they are unable or it is very difficult to provide the programs and services for the residents as they are faced with many issues and challenges on a regular and sometimes daily basis. The recreation providers in NL need support in order to do their jobs more effectively and efficiently, which will assist them in providing more positive opportunities within communities, resulting in a healthier and happier population.

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APPENDICES

APPENDIX A: SURVEY

Survey

Thank you for taking the time to complete this survey. I am asking your participation to learn more about recreation providers in Newfoundland and Labrador (NL) and the type of issues and challenges you endure while trying to provide recreation opportunities to the local community.

By completing and returning the survey you are agreeing to participate in this survey study. Your participation in this survey is voluntary, and you can refuse to answer any questions in the questionnaire without giving any reason and without ramifications. The results of your participation will be confidential and no identifying information about you will be collected. All data will be kept in confidence at the School of Human Kinetics and Recreation at Memorial University. No individual data will be reported, and only aggregate data with summaries will be available. The proposal of this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's ethics policy. If you have ethical concerns about the research (such as the way you have been treated or your rights as a participant), you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at (709) 864-2861.

There are no correct or right answers to any of the following questions. Please respond to the best of your ability, indicating how you feel about the particular topic. Please be open and honest in your responding.

Section 1

1.) Please identify the type of environment you work / volunteer in:

- Community / municipality
  - City
  - Large town (population 5000 +)
  - Medium town (population 3000 – 4999)
  - Small town (population 1000 – 2999)
  - Rural community (population under 1000)
- Community organization (Boys and Girl Club, Community Youth Network, etc.)
- Provincial organization
- Health care center
- Sport club / center

2.) Your education / training:

- High school
- Collage diploma in community recreation
- Collage diploma in a different program. Please specify: _____
- Bachelor degree in Recreation
- Bachelor degree in a different program. Please specify: _____
- Other: _____

3.) Number of years you have been employed in the recreation field:

_____

4.) If you are a volunteer, the number of years you have volunteered in the recreation field: _____

5.) Your official position / title: _____

6.) Do you have direct responsibility for a facility? YES _____ NO _____
If yes, please identify the type of facility (please select all that apply):

- o Community center / Youth center
- o Indoor Arena
- o Outdoor Arena
- o Indoor Swimming Pool
- o Outdoor Swimming Pool
- o Indoor Sport Fields
- o Outdoor Sport Fields
- o Playgrounds
- o Boating facility (canoe, kayak, etc.)
- o Hiking / Walking Trails
- o Bowling Alley
- o Gymnasium
- o Other. Please specify: _____

7.) Does your organization use facilities for your programs and services that are not operated by your organization?

YES _____ NO_____

7.) A.) If yes, to question 7, does your organization use this facility(s) to regularly house programs and services?

YES _____ NO_____

7.) B.) If yes, to question 7, does your organization have a partnership with the facility operator(s)?

YES _____ NO_____

7.) C.) If yes, to question 7 b, does your organization receive the facility for free or a reduced price?

YES _____ NO_____

8.) We are interested in understanding the issues and challenges that you face in providing recreation services, facilities and programs. Please identify the top 5 issues you are challenged with on a regular basis (*Please give a short description of the issue if necessary*):

1)

2)

3)

4)

5)

Section 2

We are interested in learning which of the following issues / challenges that were identified through a literature review, affect you the most / least. Rate the following questions 1 – 5 (1-being low/no and 5- being high/yes) OR select N/A if this isn't an issue / challenge you experience

1.) How important is this issue to the delivery of quality recreation programs and services at your organization?

Rate Scale Defined: if an issue listed below is very challenging for you, limiting the programs / service you (your community / organization) are able to offer, then select 5 (High). If an issue is somewhat limiting or a barrier to the programs / services you are able to offer, then select 1, 2, 3 or 4, depending on your feeling towards the severity of the issue/challenge. If an issue is not challenging and you do not see it as an issue, then N/A

Issue:	N/A	Low				High
Budget - Having a sufficient budget for each program and service you deliver	N/A	1	2	3	4	5
Staffing - Having the staff to efficiently deliver quality programs and services	N/A	1	2	3	4	5
Facilities - Having the proper facility(s) to house programs and services	N/A	1	2	3	4	5
Inclusion - Able meet all the needs of the community	N/A	1	2	3	4	5
Planning - Being able to plan efficiently	N/A	1	2	3	4	5
Understanding and Support - Having a support system (board, council, participants, etc.) that understands the benefits of recreation	N/A	1	2	3	4	5
Partnerships - Working with other organizations / associations to provide programs and/or services	N/A	1	2	3	4	5
Marketing	N/A	1	2	3	4	5

- Having the resources to effectively communicate to the public about programs and services						
Evaluation - Being able to regularly evaluate efforts	N/A	1	2	3	4	5
Professional Development Support - Having the resources to attend meaningful training opportunities	N/A	1	2	3	4	5

2.) Do you have the resources to address the issues / challenges that you listed in question 1 to be effecting your community / organization?

Issue:	N/A	Low /No				High/ Yes
Budget	N/A	1	2	3	4	5
Staffing	N/A	1	2	3	4	5
Facilities	N/A	1	2	3	4	5
Inclusion	N/A	1	2	3	4	5
Planning	N/A	1	2	3	4	5
Understanding and Support	N/A	1	2	3	4	5
Partnerships	N/A	1	2	3	4	5
Marketing	N/A	1	2	3	4	5
Evaluation	N/A	1	2	3	4	5
Professional Development Support	N/A	1	2	3	4	5

Section 3:
We would like to learn more detailed information on each issue/challenge.

Please complete the following questions using the rating scale:
1-being NO or Low and 5- being YES or HIGH, depending on the nature of the question. Select N/A if this isn't an issue / challenge you experience OR if the question doesn't apply to you.

Issue 1: Budget

		Low/No					High/Yes
A	Do you have a sufficient budget for each program and service you deliver?	1	2	3	4	5	N/A
B	Would changing the user fees of your facility / programs / services be beneficial to your budgeting issue?	1	2	3	4	5	N/A

C	Would reviewing the operating cost of your facility / programs / services have a positive effect on your budgeting issue?	1	2	3	4	5	N/A
D	Would your organization benefit from additional grant funding?	1	2	3	4	5	N/A
E	If yes, to question C, do you have the resources (staff, skills, etc.) to seek the additional funding you require?	1	2	3	4	5	N/A

Issue 2: Staffing

		LOW/NO					**HIGH/YES**
A	Does your organization have the number of staff or volunteers to efficiently deliver quality programs and services?	1	2	3	4	5	N/A
B	How would you rate the skills of your board of directors/ town council? (Recreation competences needed to review / oversee the organization)	1	2	3	4	5	N/A
C	Do new/potential workers of your organization have the skills required to do their job efficiently without additional training?	1	2	3	4	5	N/A
D	Does your organization offer employees regular training?	1	2	3	4	5	N/A
E	Do the workers in your organization seem satisfied in their current position?	1	2	3	4	5	N/A
F	Does your organization experience frequent staff turnover?	1	2	3	4	5	N/A

G) If you answered 3, 4 or 5 to question E, please comment on why you feel your organization experiences frequent staff turnover:

_____

_____

Issue 3: Facilities

		LOW/NO					HIGH/YES
A	Do you have the sufficient number of facilities or spaces to house all the programs and service?	1	2	3	4	5	N/A
B	Does the locations have sufficient amount of space for the number of participants?	1	2	3	4	5	N/A
C	Does your facility(s) (the building you use) have an inclusive structure? *(Built by code for persons with disabilities)*	1	2	3	4	5	N/A
D	Is the location of the facilities accessible to everyone in the community?	1	2	3	4	5	N/A

Issue 4: Inclusion

		LOW/NO					HIGH/YES
A	How well does your organization meet the needs of your community from all income brackets (i.e., low, middle and high income)? *Please rate*	1	2	3	4	5	N/A
B	Does your organization have the equipment to meet all the needs of the community?	1	2	3	4	5	N/A
C	How inclusive would you rate your organizations current programs and services?	1	2	3	4	5	N/A
D	Would additional funding	1	2	3	4	5	N/A

	positively benefit your organizations ability to be inclusive / more inclusive?						
E	Rate how additional training may positively benefit you organization ability to be inclusive / more inclusive?	1	2	3	4	5	N/A

Issue 5: Planning

		LOW/NO					HIGH/YES
A	Please rate your organizations ability to plan effectively?	1	2	3	4	5	N/A
B	Do you have the time to plan effectively?	1	2	3	4	5	N/A
C	How would you rate your organizations overall knowledge and skills of planning?	1	2	3	4	5	N/A
D	How would you rate how well your organization evaluates programs / services?	1	2	3	4	5	N/A

Issue 6: Understanding and Support

		LOW/NO					HIGH/YES
A	How supportive is your board of directors / town council?	1	2	3	4	5	N/A
B	How would you rate the participants (community's) support for new recreation programs and services?	1	2	3	4	5	N/A
C	How would rate your organizations ability to marketing the benefits of recreation to your community?	1	2	3	4	5	N/A

Issue 7: Marketing

		LOW/NO					HIGH/YES
A	Do you feel your organization has the budget to effectively communicate to the public about programs and services?	1	2	3	4	5	N/A
B	Does the employees or volunteers of your organization have the training and skills to effectively communicate to the public about programs and services?	1	2	3	4	5	N/A
C	Please rate your organizations marketing policies? *(If you don't have a policy please select 1)*	1	2	3	4	5	N/A
D	Is marketing built into your organizations program plan?	1	2	3	4	5	N/A
E	Is marketing budgeted for programs / services?	1	2	3	4	5	N/A
F	Please rate how you feel additional marketing could positively effect your organizations programs and services?	1	2	3	4	5	N/A

G) Please identify the marketing venues regularly use (Select all that apply):

- o Newsletter
- o Local newspaper
- o Local radio
- o Community channel
- o Poster / flyer
- o Other (please list all additional not identified on the list):_____

Issue 8: Partnerships

		LOW/NO					HIGH/YES
A	How often does your organization work with	1	2	3	4	5	N/A

	partners to deliver programs and services?						
B	How would you rate your partnership relationships?	1	2	3	4	5	N/A

C) How often do you evaluate your partner relationships?
____ Quarterly _____6 month's _____Yearly _____Never
_____Not sure _____Other

Issue 9: Evaluation

		LOW/NO					HIGH/YES
A	Does you organization have the time to regularly evaluate; staff, programs, services, facilities, etc.?	1	2	3	4	5	N/A
B	Does the employees or volunteers of your organization have the training and skills to effectively do evaluations? (Staff, programs, services, facilities, etc.)	1	2	3	4	5	N/A
C	Please rate how your ability to evaluate is effected by no or low financial resources?	1	2	3	4	5	N/A
D	Does your organization do regular needs assessments?	1	2	3	4	5	N/A

E) How often does you organization conduct a needs assessment?
_____Yearly _____Every 2 years _____Every 3 years _____Every 5 years _____Other

F) How regularly your organization evaluates programs and services?
_____Quarterly _____6 month's _____Yearly
_____at the beginning, middle and end of programs
_____Never _____Other

Issue 10: Professional Development Support

		LOW/NO					HIGH/YES
A	When you want to take part in professional development opportunities do you have the staff to support your time away?	1	2	3	4	5	N/A

B) How often do you get to participate in professional development opportunities?
_____ Times per year

Please list the type(s) of professional development opportunities you take part in:

_____

_____

Comments:

_____

_____

_____

C) What is you biggest barrier for not attending training opportunities? Please rate 1 – 5 (1 being the biggest barrier)

_____ Time away from the office
_____ Staff support (nobody to cover you while you are away)
_____ Board / council support
_____ Funding
_____ Other

APPENDIX B: FACILITATED BREAKOUT SESSION INTERVIEW GUIDE

Facilitated Breakout Session Interview Guide

Timeline:

- Introduction of facilitator and purpose of the working group - 8 minutes
- Consent form distribution and collection - 5 minutes
- Presentation of findings from literature review and survey - 15 minutes
- Group questions - 30 minutes
- Closing - 2 minutes

TOTAL: 60 Minutes

Facilitated Breakout Session Questions:

Question 1: *20 minutes*

Please discuss and identify possible solutions / recommendations for your issue and/or challenge.

- *Questions to help guide your discussion:*
  a. What makes this an issue / challenge for you?
  b. List the resources you will need to overcome this issue / challenge
  c. Would you need support from an outside source? If so, who and why? (i.e. Local businesses, RNL, School system, provincial government, etc.)

Question 2: *10 minutes*

Resources / supports:
List the 5 things you collectively feel are currently supported in the recreation field. Please give your reasoning.

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Muscle and Joint Function in Human Locomotion

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Key Words

walking, running, gait biomechanics, musculoskeletal model, inverse dynamics, forward simulation

Abstract

This review describes how computational modeling can be combined with noninvasive gait measurements to describe and explain muscle and joint function in human locomotion. Five muscles—the gluteus maximus, gluteus medius, vasti, soleus, and gastrocnemius—contribute most significantly to the accelerations of the center of mass in the vertical, fore-aft, and medio-lateral directions when humans walk and run at their preferred speeds. Humans choose to switch from a walk to a run at speeds near 2 m s^{-1} to enhance the biomechanical performance of the ankle plantarflexors and to improve coordination of the knee and ankle muscles during stance. Muscles that do not span a joint can contribute to the contact force transmitted by that joint and therefore affect its stability. In walking, for example, uniarticular muscles that cross the hip and ankle act to create the adduction moment at the knee, thereby contributing to the contact force present in the medial compartment.

Contents

INTRODUCTION

Walking is a task that most people perform with ease. Although seemingly simple, it is an extraordinarily complex skill that takes years to develop. The various actions of the leg muscles are exquisitely timed to lift and accelerate the body while balancing it about a base of support. Gait-analysis techniques have been used for more than a century to provide quantitative information on the kinematics and kinetics of locomotion, yet only recently has a more complete understanding of muscle and joint function emerged (1–5). Rapid increases in computing power combined with recent advances in imaging and more efficient algorithms for modeling and simulation of movement have enabled more detailed analyses of muscle and joint function (6–9).

This review addresses some critical issues related to computational modeling of gait. Although gait analysis has led to a more objective assessment of locomotion biomechanics, its ability to quantify function is limited in two respects. First, the musculoskeletal system is mechanically redundant, as each joint is spanned by several muscles, and a net joint moment can be produced by many combinations of muscle forces. For example, more than 15 muscles control 3 degrees of freedom at the hip. Also, biarticular muscles such as the hamstrings cross two joints—the hip and the knee—and so contribute to the net moments exerted about both joints simultaneously. It is therefore not possible to discern the actions of individual muscles from calculations of net joint moments alone. Second, muscle electromyography (EMG) recordings characterize the sequence and timing of muscle activity, but there is no known correlation between the level of a measured

EMG: electromyography

EMG signal and the amount of force that the muscle might be producing during a dynamic contraction.

There are well-founded misgivings also about computational modeling. The response of a model is influenced, sometimes to a large extent, by the values assumed for its parameters, and this information is often difficult, and sometimes impossible, to obtain by direct measurement. Furthermore, model predictions of unmeasurable quantities, such as muscle forces, cannot be validated by noninvasive measurements. Thus sometimes only a moderate level of confidence can be placed in calculations obtained from a model.

There is no perfect path to take, but one sensible way to proceed is to combine the power of computational modeling with available measurements to determine information that is not readily obtainable from an experiment. Recent work in the study of movement based on this approach is described below, together with some results related specifically to walking and running. We begin by describing a framework for the noninvasive evaluation of muscle and joint loading based on inverse- and forward-dynamics techniques. We then highlight two significant problems related to computational modeling of movement: (*a*) accurate estimation of model parameters in vivo and (*b*) experimental validation of model response. Finally, we demonstrate how the computational modeling approach can be used to address the following fundamental questions related to muscle and joint function in human locomotion:

- How do muscles coordinate motion of the center of mass during gait?
- Which muscles control mediolateral balance in walking?
- Why do humans choose to switch from a walk to a run at speeds near 2 m s^{-1}?
- Which muscles power running, particularly at the higher speeds?
- How does leg-muscle action influence lower-limb joint loading in walking and running?

NONINVASIVE EVALUATION OF MUSCLE AND JOINT FUNCTION

What Is Needed to Determine Muscle and Joint Function In Vivo?

Muscle and joint function can be determined when the following information is available: (*a*) accurate measurements of the forces applied to the body by the ground, (*b*) accurate measurements of body-segmental motion, and (*c*) accurate knowledge of muscle and joint contact loading. In gait-analysis experiments, force platforms are used to measure ground reaction forces, while video-based motion-capture techniques are applied to monitor the 3D positions and orientations of the body segments. Errors associated with nonrigid movement of the soft-tissue interface between the skin markers and the underlying bone, referred to as soft-tissue artifact, limit the accuracy with which motion-capture techniques can be used to record 3D joint motion in vivo (10–12). More recent methods for recording dynamic joint motion in vivo include X-ray fluoroscopy and magnetic resonance imaging (MRI) (13, 14). X-ray fluoroscopy enables joint translations and rotations to be measured to accuracies of 1 mm and 1 degree, respectively, in the image plane, although errors perpendicular to the image plane can be much larger (15). Commercial fluoroscopy systems operate at relatively low frame rates (up to 30 Hz), limiting the precision with which joint motion can be measured during more rapid movements such as running. These systems also constrain the natural movement of the subject, so the potential movement artifact caused by the measurement system should be evaluated in the same context as accuracy and precision (16).

Noninvasive evaluation of musculoskeletal function also requires accurate knowledge of muscle and joint loading. Some studies have reported on in vivo measurements of tendon, ligament, and joint contact forces, but the results are limited to a small number of accessible structures [e.g., the Achilles tendon (17) and the anterior cruciate ligament (ACL) of the knee (18)] as well as

small numbers of subjects (19–21). Computational modeling is the only practicable method for determining muscle and joint contact forces in vivo.

ACL: anterior cruciate ligament

Integrating Gait Experiments and Modeling to Evaluate Muscle and Joint Loading

The first musculoskeletal models of the body appeared nearly 45 years ago (22), but progress has really accelerated in the past 10 years owing to the vast increases in computing power and the availability of more efficient and robust algorithms for modeling, image reconstruction, and numerical simulation (6, 9). Musculoskeletal modeling has been applied to a wide range of problems in movement science, including (*a*) understanding how geometry (e.g., moment arms) and muscle-tendon properties independently affect a muscle's ability to develop moment about a joint (23); (*b*) evaluating a muscle's capacity to accelerate the body joints in various tasks such as walking, jumping, and cycling (1, 4, 24); and (*c*) analyzing how orthopedic surgical procedures, such as osteotomies and muscle-tendon transfers, alter the lengths and moment arms of muscles (25). Nonetheless, the most common use of modeling has been in the determination of muscle and joint loading (8, 26, 27). Accurate knowledge of muscle forces could improve the diagnosis and treatment of patients with movement disabilities. Accurate information on the loading patterns incurred by the muscles and bones would also inform the design of joint replacements and tissue-engineered constructs that are developed to replace soft tissues that are damaged as a result of injury.

Figure 1 illustrates a framework commonly used to evaluate muscle and joint loading in human locomotion. In studies of walking, for example, measurements of body motions and ground reaction forces are used in conjunction with a musculoskeletal model of the body to determine muscle forces over one gait cycle. The calculated values of the muscle forces are then applied to more detailed models of the lower-limb joints to determine the corresponding forces and stresses acting on the bones (28–30). Muscle forces can be calculated using inverse- or forward-dynamics techniques. In the inverse method, kinematic and force-plate data are applied to a recursive Newton-Euler inverse-dynamics algorithm to calculate the net moments exerted about the ankle, knee, and hip (31). Muscle forces are then found either by reducing the number of muscles spanning each joint until the muscle force–joint moment problem can be solved uniquely (22, 32) or by applying optimization theory to solve an indeterminate problem (33, 34).

For a system of n joints actuated by m muscles, a set of linear equations can be formed to describe the relationships between the net joint moments and muscle forces:

$$\begin{bmatrix} T_1 \\ T_2 \\ . \\ T_n \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & . & r_{1m} \\ r_{21} & r_{22} & . & r_{2m} \\ . & . & . & . \\ r_{n1} & r_{n2} & . & r_{nm} \end{bmatrix} \begin{bmatrix} F_1^M \\ F_2^M \\ . \\ F_m^M \end{bmatrix}. \quad (1)$$

In this set of equations, F_i^M is the force developed by muscle i, r_{ji} is the moment arm of muscle i about joint j, and T_j is the torque exerted about joint j. Both agonist and antagonist muscles contribute (unequally) to the net moment developed about a joint, leading to a greater number of muscle forces than joint moments. Because $m > n$ in Equation 1, the moment-arm matrix cannot be inverted to determine a unique set of muscle forces corresponding to the prescribed joint moments. Optimization theory is often used to solve this indeterminate problem, whereby muscle forces are calculated by minimizing, for example, the sum of the squares of muscle stresses (34), or equivalently, the sum of the squares of muscle activations (35, 36).

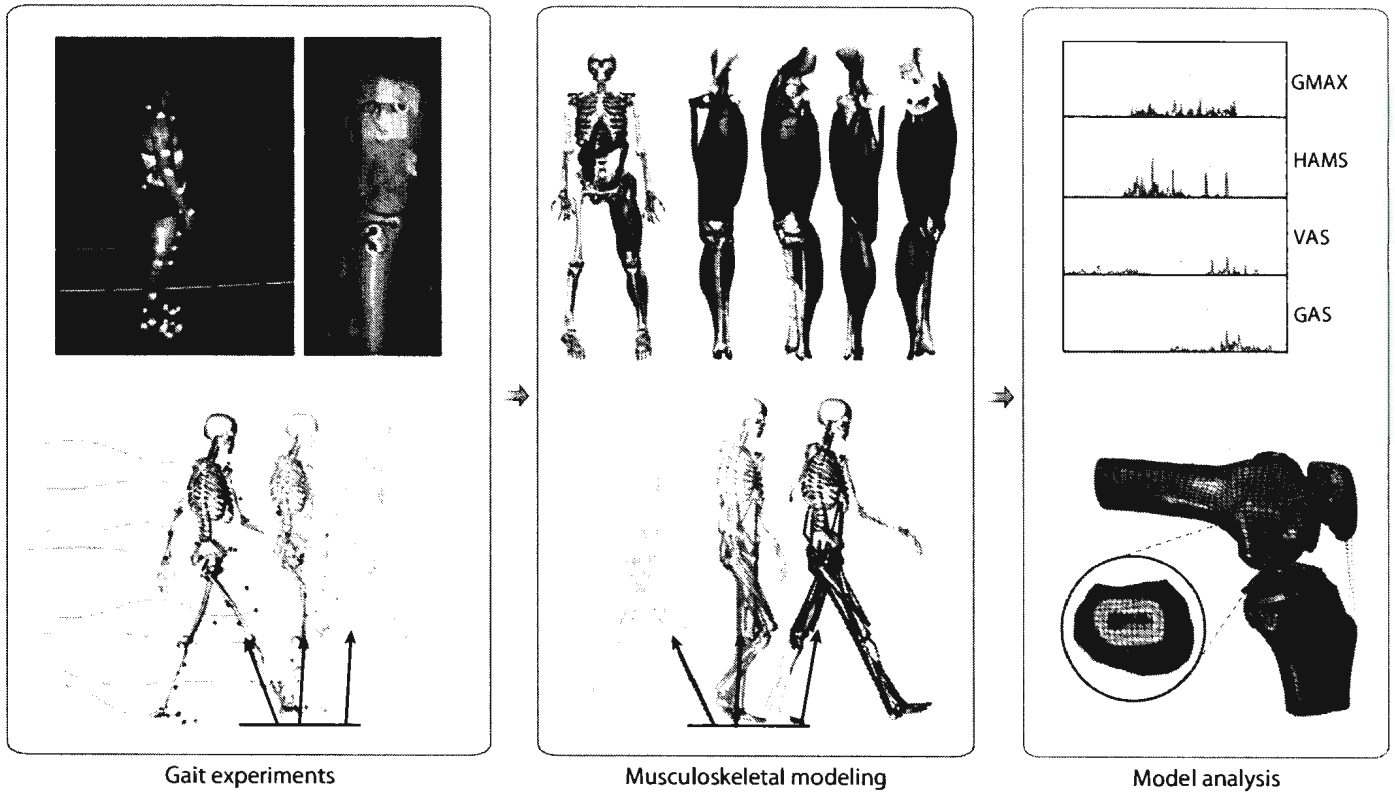

Figure 1

Schematic diagram illustrating a framework for studying muscle and joint function in human locomotion. Gait experiments are performed to measure body-segmental motion and ground reaction forces; 3D musculoskeletal models of the body are used in conjunction with gait measurements to determine lower-limb muscle and joint contact loading; model output is analyzed to describe and explain muscle and joint function.

Because the performance criterion is generally unknown, investigators sometimes use muscle EMG measurements to calculate muscle forces without resorting to optimization (37, 38). However, EMG data are not always available, particularly from muscles that are deep lying. Indeed, EMG-driven models of the lower limb have focused on muscles that cross the ankle and the knee, presumably because these muscles are amenable to surface EMG measurements (38, 39). Even if activity could be recorded from all the muscles of interest, how accurately a measured EMG signal models muscle activation is unclear; an EMG signal represents the summed effect of activity from all the motor units, but the measurement is most often made locally over a small region of the muscle belly.

Forward dynamics is fundamentally different from inverse dynamics because muscle forces are obtained by integrating the equations of motion forward in time using neural excitation signals as inputs. Early attempts to apply this approach involved predicting all quantities of interest simultaneously (i.e., joint motions, ground reaction forces, muscle forces, muscle activations, and neural excitations) (40, 41). However, this dynamic-optimization approach suffers from the "curse of dimensionality"; for example, a dynamic-optimization solution for walking that was based on a complex 3D musculoskeletal model of the body incurred 3 months of CPU time on a 24-processor parallel machine (42, 43).

A more efficient implementation of the forward method is to solve a parameter-optimization problem, in which muscle forces are calculated by prescribing trajectories of the joint motions and ground reaction forces that the model must track (44–46). In the context of **Figure 1**, measurements of body-segmental motions and ground reaction forces are used to drive a neuromusculoskeletal model of the body in a forward simulation, and parameter optimization is used to determine the muscle forces responsible for the observed gait pattern. Because the model is open-loop unstable, feedback control theory is used to produce a stable simulation of the task. Ground reaction forces are applied at the measured center of pressure under each foot, and differences between the measured and calculated joint angles are minimized to constrain the model to track the measured joint trajectories (45, 46). The muscle force–joint moment indeterminate problem is solved by applying a rule that is hypothesized to model the goal of the task (e.g., minimizing muscle stress). The selection of an appropriate cost function is even more critical when analyzing patients with conditions that induce gait-pattern changes. A parametric approach that finds solutions for joint contact forces through a range of physiological muscle forces is well suited to studying pathological function because the problem can be formulated independently of an optimization criterion (47, 48).

Are Dynamic Simulations of Movement Needed to Calculate Muscle Forces?

Previous attempts to determine muscle forces in human movement have overwhelmingly applied inverse dynamics. One criticism leveled at this method is that the results depend on the accuracy of the kinematic data recorded during a gait experiment. The difficulty in accurately estimating joint accelerations from measurements of body position can introduce errors in the calculated values of the joint moments and hence the muscle forces. Forward simulations aim to minimize the effect of measurement error by tracking measured values of the joint displacements to obtain improved estimates of joint accelerations (45, 46). Although either approach is readily implemented in the context of **Figure 1**, it is important to be aware of the circumstances under which inverse and forward dynamics may produce different results.

A direct comparison of muscle-force predictions obtained from inverse and forward dynamics was made for normal walking (35). Net joint moments obtained from a dynamic-optimization solution were used as the inputs to a series of analogous inverse-dynamics problems to compute

muscle forces for one gait cycle. The forward and inverse solutions were similar in their predictions, suggesting that either method may be used to determine muscle forces in normal walking. **Figure 2** shows the results of a similar comparison made for running at the preferred speed of 3.5 m s^{-1} (T. Dorn and M.G. Pandy, unpublished analysis). Although differences in the absolute values of the muscle forces are evident, muscle coordination predicted by the two methods is essentially the same. These results suggest that inverse dynamics may be applied with the same level of confidence as forward dynamics when calculating leg-muscle forces at faster speeds of locomotion.

PCSA: physiological cross-sectional area

The Model Parameter Problem

The accuracy of any modeling approach is determined, in part, by the values of the parameters assumed in the model. Models of the musculoskeletal system are defined by the equations that describe the structure of the system and the interactions that arise between the system and its environment. Understanding the model predictions' sensitivity to variations in the values of the model parameters is important for several reasons. Body-segment anthropometry, bone geometry, muscle-tendon architecture, and the material properties of the soft tissues in and around the joints can vary significantly among people, and the values of some parameters—particularly those that describe muscle-tendon architecture and the mechanical properties of ligament and cartilage—cannot be obtained by direct measurement noninvasively. Muscle-fiber lengths can be measured by dissection of cadaver specimens (49–51), but these quantities are difficult to measure in living subjects, even when noninvasive techniques such as MRI and ultrasound are used (52, 53). Measurements of tendon rest lengths are difficult to obtain even by gross dissection because of the difficulty in distinguishing the aponeurotic part of tendon from the muscle belly proper, and also because the tendon may be stretched when postmortem measurements are made. The mechanical properties of articular cartilage are most frequently measured by performing compression, shear, and indentation experiments on cartilage-bone blocks ex vivo (see References 54 and 55 for reviews), although recent studies have shown that indentation tests may also be performed in vivo via handheld arthroscopic probes (56). The force-length properties of tendons and ligaments can only be determined in vitro after tensile experiments have been conducted on tendon- and ligament-bone preparations (see References 57 and 58 for reviews).

Measured values of fiber length and physiological cross-sectional area (PCSA) for some of the lower-limb muscles thought to be important in walking are summarized in **Table 1**. There is a noticeable spread in the data for PCSA. For example, measurements obtained from cadavers show that the PCSA of vastus lateralis ranges from 30.6 cm^2 to 40.4 cm^2 (49, 51), whereas data obtained from MRI performed on young athletes indicate an average PCSA of nearly 70 cm^2 (59). Furthermore, all the fiber lengths of the knee extensors, knee flexors, and ankle plantarflexors measured recently in 21 cadavers (50) were longer, and in some instances as much as two times longer, than lower-limb fiber lengths reported previously (51). The authors (50) stated that comparison with the data reported by Wickiewicz et al. (51) is "particularly important because [it is] the most widely used data set for musculoskeletal modeling. Their data were presented almost 30 years ago as a pilot project by a medical student working in a muscle laboratory..." (50, p. 1080).

If measurements of skeletal-muscle architecture cannot be obtained accurately in vivo, how should one proceed? One option is to estimate the values of these parameters by combining experiments, modeling, and optimization. Values of muscle-fiber length, tendon rest length, and muscle PCSA have been calculated by minimizing the differences between the net joint moments produced in a model and those obtained from inverse dynamics through motion-analysis data

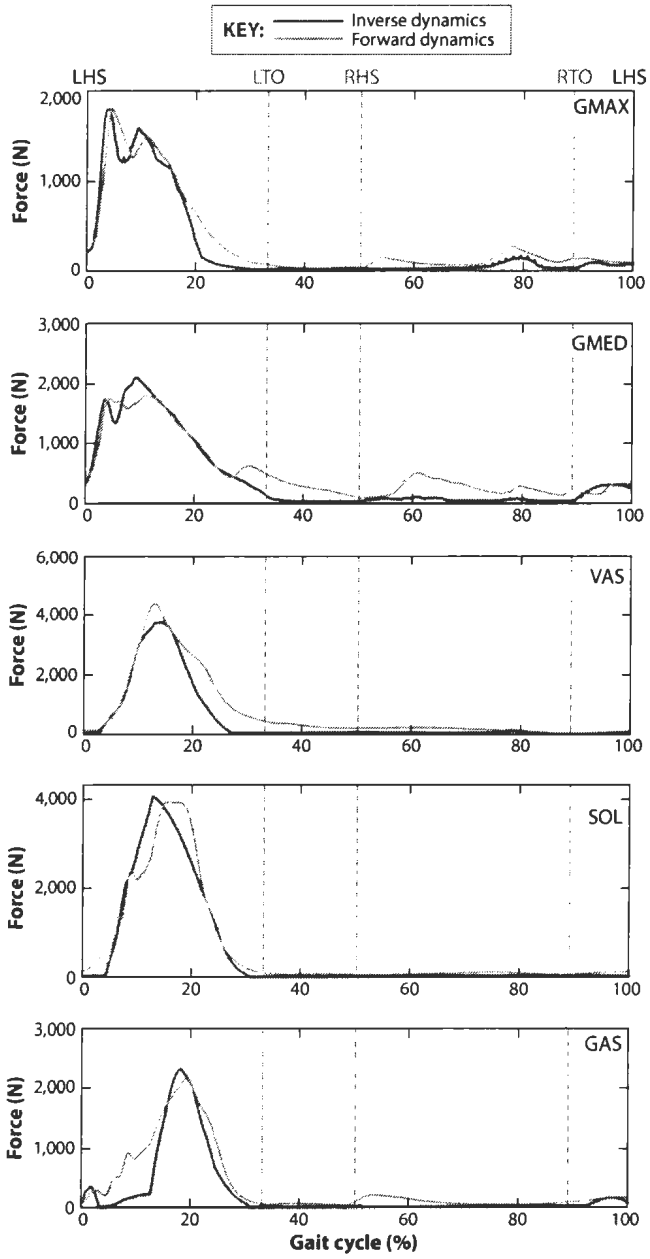

Figure 2

Comparison of muscle forces calculated using inverse and forward dynamics for running at the preferred speed of 3.5 m s^{-1}. The results for inverse dynamics were obtained by using optimization to decompose the net moments computed about the hip, knee, and ankle. The results for forward dynamics were obtained by tracking measured gait data using the method of computed muscle control (CMC) (45). Note that both methods solve the muscle-distribution problem by using static optimization. The CMC method, however, performs a forward simulation of running dynamics and also takes into account the effect of muscle-activation dynamics. Symbols defining the major gait events: LHS, heel-strike of the ipsilateral (left) leg; LTO, left toe-off; RHS, heel-strike of the contralateral (right) leg; RTO, right toe-off. Muscle symbols: GMAX, gluteus maximus; GMED, gluteus medius; VAS, vasti; SOL, soleus; GAS, gastrocnemius.

Table 1 Values of muscle-fiber length and muscle physiological cross-section area reported in the literature

Muscle	Muscle-fiber length (cm)				Muscle PCSA[c] (cm^2)			
	Wickiewicz[a]	Friederich[a]	Ward[a]	Tate[b]	Wickiewicz[a]	Friederich[a]	Ward[a]	Tate[d]
Gluteus maximus (superior)	–	10.8	–	–	–	17.4	–	–
Gluteus maximus (middle)	–	13.0	–	–	–	14.6	–	–
Gluteus maximus (inferior)	–	13.9	–	–	–	14.1	–	–
Gluteus medius (anterior)	–	4.7	–	–	–	19.0	–	–
Gluteus medius (middle)	–	6.8	–	–	–	13.3	–	–
Gluteus medius (posterior)	–	6.0	–	–	–	15.4	–	–
Vastus medialis	7.0	7.8	9.7	–	21.1	41.2	20.6	46.1
Vastus intermedius	6.8	7.6	9.9	–	22.3	49.6	16.7	54.3
Vastus lateralis	6.6	8.0	9.9	–	30.6	40.4	35.1	69.9
Soleus	2.0	3.0	4.4	–	58.0	122.2	51.8	–
Gastrocnemius (lateral)	5.1	6.1	5.9	–	–	11.5	9.7	23.9
Gastrocnemius (medial)	3.5	3.9	5.1	–	32.4	33.8	21.1	43.7

[a]Data reported by Wickiewicz et al. (51), Friederich & Brand (49), and Ward et al. (50) were obtained by dissection of cadaver specimens.
[b]Data reported by Tate et al. (59) were obtained from magnetic resonance imaging performed on living subjects. Muscle-fiber lengths were not measured by Tate et al. (59).
[c]Abbreviation: PCSA, physiological cross-sectional area.
[d]Muscle PCSA was calculated using muscle-fiber lengths reported by Ward et al. (50).

(37, 60). At the least, it is important to understand the model calculations' sensitivity to variations in the values assumed for the model parameters (47, 61–65). A recent study (62) quantified the effects of small changes in muscle-fiber lengths, tendon rest lengths, and muscle PCSA on model estimates of muscle forces in gait. Values of muscle-fiber length, tendon rest length, and muscle PCSA were perturbed in a 3D model of the body similar to the one shown in **Figure 3**, and an inverse-dynamics problem was solved to compute the corresponding changes in leg-muscle forces. Perturbations were made in increments of 2.5% of the nominal value assumed for each parameter, up to a maximum change of 10%.

Muscle-force estimates were most sensitive to changes in tendon rest lengths and least sensitive to changes in muscle PCSA. Changes in the tendon rest lengths of the knee extensors (vasti) and one of the ankle plantarflexors (soleus) affected the calculated values of muscle force most significantly, although model sensitivity to changes in the fiber length of the vasti was also high. These results stress the importance of obtaining reliable estimates of tendon rest lengths and muscle-fiber lengths, particularly for actuators considered to be the prime movers of the leg (see Lower-Limb Muscle Function in Walking and Running, below). Because muscle-force estimates are relatively insensitive to changes in muscle PCSA, approximate methods, such as geometric scaling, may be sufficient in this regard, even though accurate measurements of muscle volumes can be obtained noninvasively through MRI. Finally, the ranges of step-to-step and intersubject variations in gait patterns could potentially exceed the sensitivity of the model calculations to changes in specific anatomical or physiological properties (67).

When Should Subject-Specific Models Be Used to Evaluate Muscle and Joint Function?

Most attempts to simulate gait have utilized generic musculoskeletal data based on estimates derived from average adult anatomy (4, 5, 32, 48, 68, 69). Because body anthropometry, bone

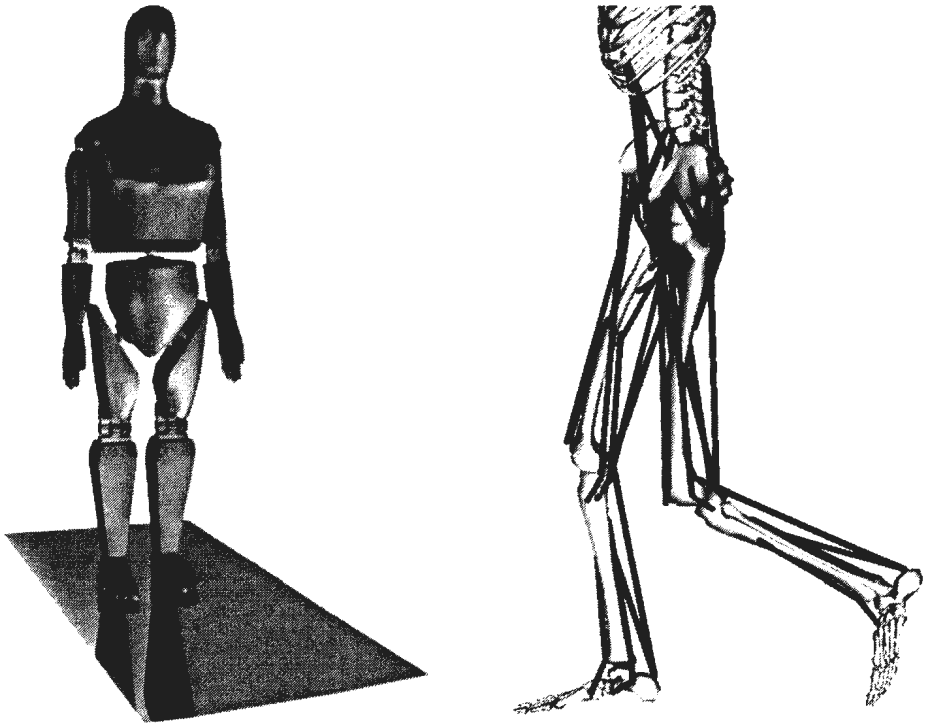

Figure 3

Three-dimensional muscle-actuated model of the body used to simulate gait. The skeleton was represented as a 10-segment, 23-degree-of-freedom linkage. Each hip was modeled as a ball-and-socket joint, each knee as a hinge joint, each ankle-subtalar complex as a universal joint, and each metatarsal joint as a hinge. The locations of the joint centers and the orientations of the joint axes in the model were found by minimizing differences between the positions of surface markers located on the subject and virtual markers defined in the model (66). Subject-specific models of the skeleton were created by scaling the segmental inertial properties of the model to each subject's height and weight. The model was actuated by 54 muscle-tendon units, with each actuator represented as a Hill-type muscle in series with a tendon. The force-generating properties, attachment sites, and paths of all the muscles in the model were the same as those identified in References 43 and 68.

geometry, muscle paths, muscle-tendon architecture, and soft-tissue properties can vary substantially among individuals, predictions of muscle and joint function ought to reflect these differences. Few attempts have been made to incorporate anatomical data obtained from children and older adults in a musculoskeletal model of movement (see, for example, Reference 70). In addition, relatively few studies have used patient-specific models to simulate gait disorders resulting from conditions such as cerebral palsy, stroke, and knee osteoarthritis (71–73).

Whether a subject-specific model is needed for accurate evaluation of muscle and joint function depends on the purpose of the model. If the aim is to use musculoskeletal models for surgical planning and clinical decision making (e.g., 74, 75), then some degree of specificity must be incorporated into the modeling process. Children with cerebral palsy, for example, frequently exhibit bone deformities, such as femoral anteversion, that alter the moment arms of the leg muscles (71). Because the moment produced by a muscle is proportional to the muscle's moment arm, small changes in moment arm can affect the capacity of the muscle to cause joint rotation.

Therefore, predictions of muscle function should be interpreted with caution when generic models are used to simulate the walking patterns of patients with musculoskeletal disorders (76).

Subject-specific models also are likely to be needed in studies of joint function. How articular-contact geometry and soft-tissue properties are represented in a model of joint biomechanics can influence predictions of muscle, ligament, and joint loading (65, 77–79). At the knee, for example, model calculations of cruciate-ligament forces are most sensitive to the reference strains assumed for the ligaments (80); estimates of patellofemoral joint contact forces depend on how the shapes of the patellar facet and trochlear groove are represented in 3D (77); and the calculated values of tibiofemoral contact pressures are sensitive to the sizes, shapes, and material properties assumed for the medial and lateral menisci (81, 82). Certainly, valid estimates of joint contact stresses necessitate accurate descriptions of joint contact geometry and of the material properties of the contacting surfaces, and therefore require the use of more sophisticated modeling techniques such as finite-element analysis (83–87).

If the purpose is to study muscle coordination of locomotion in able-bodied persons, then scaled-generic models may suffice. In walking at the preferred speed, for example, the patterns of joint kinematics, ground reaction forces, joint moments, and muscle activity are stereotypic. One would expect, therefore, that leg-muscle coordination (e.g., how each muscle accelerates the body's center of mass during the stance phase) would also be invariant across a group of able-bodied adults. A generic model scaled to accommodate differences in subject anthropometry was used recently to simulate young children walking at different speeds (70). The model predicted patterns of muscle coordination that closely resembled those obtained previously using a generic model of an adult male subject (3, 4, 44).

The Model Validation Problem

Model predictions of muscle forces are usually validated against EMG records of muscle activity. In one study (88), model calculations of leg-muscle forces in cats walking at different speeds were compared with direct measurements of these quantities obtained from the same animals. The predicted muscle forces did not agree well with the experimentally determined muscle forces, possibly because changes in force sharing that occur between steps and at different speeds were largely ignored in the theoretical models tested.

Internal contact-force measurements obtained from instrumented joint replacements offer another means of evaluating model calculations of muscle forces (89, 90). In vivo measurements of knee-joint loading acquired from an instrumented implant were used recently to evaluate model predictions of knee muscle forces in walking (90). Joint motion, ground reaction forces, and tibial contact forces were recorded simultaneously from a single subject walking at slow, normal, and fast speeds. The model shown in **Figure 3** was used to determine lower-limb muscle forces for each walking speed. The predicted knee muscle forces were then applied to a 3D knee-implant contact model to calculate tibial contact forces. Peak total (medial plus lateral) contact forces measured for the subject ranged from 1.9 BW for slow walking to 2.5 BW for fast walking. Calculated and measured tibial contact forces were in good agreement for all three walking speeds. Average root mean square (RMS) errors for the medial, lateral, and total contact forces were, respectively, 0.21 $\pm$ 0.06 BW, 0.17 $\pm$ 0.05 BW, and 0.27 $\pm$ 0.07 BW, calculated over one gait cycle and across all walking trials. Although the model reproduced the time course of knee-joint loading for all three walking speeds, this is a necessary, but not sufficient, condition for concluding that the corresponding knee muscle forces were also determined accurately. Ten muscles actuated the model knee and gave rise to the two contact forces calculated in the medial and lateral compartments, implying that many different combinations of knee muscle forces may

yield the same pattern of knee-joint loading. Comparisons of the muscle-force calculations with measured EMG activity can further increase confidence in the model results.

Direct measurement of joint contact forces is limited to a small number of subjects; however, there are other ways to proceed. If the goal of the motor task can be stated with a good deal of certainty (e.g., jump as high as possible), forward dynamics may be used to evaluate and refine the structure of the model. A model similar to that shown in **Figure 3** was used to simulate both vertical jumping and walking without altering any of the parameters assumed in the model (43, 68, 91). Because the performance criterion for walking is ambiguous, the model was used first to solve a dynamic-optimization problem for maximum-height jumping. Once the problem for jumping was solved, and the response of the model was compared against experiment, the same model was then used with greater confidence to simulate walking.

Alternatively, model response can be evaluated by simulating an in vitro experiment in which many variables of interest can be measured directly (79, 80). In one study, a 3D specimen-specific validation of ACL strain was performed by comparing predicted ACL strain with measurements obtained from the same cadaver knee under identical conditions of loading and limb alignment (79). The validated model then was used to predict ACL strains under physiological loading conditions to simulate a run-to-stop single-leg landing. Incidentally, deceleration forces associated with sudden stopping were found to reduce ACL strains owing to the posteriorly directed shear forces applied by the ground reaction force to the leg. These findings are similar to those obtained from model simulations of a drop-landing task (92).

Biomechanical Coupling and Movement Coordination

Models of movement usually represent the skeleton as a system of articulated rigid bodies joined together by models of the joints. The governing equations of motion for any musculoskeletal model of the body can be written as

$$M(\underline{q})\ddot{\underline{q}} + C(\underline{q})\,\dot{\underline{q}}^2 + \underline{G}(\underline{q}) + R(\underline{q})\,\underline{F}^M + \underline{E}(\underline{q}, \dot{\underline{q}}) = \underline{0}, \tag{2}$$

where $\underline{q}$, $\dot{\underline{q}}$, and $\ddot{\underline{q}}$ are vectors of angular and linear joint displacements, velocities, and accelerations, respectively; $M(\underline{q})$ is the system mass matrix and $M(\underline{q})\ddot{\underline{q}}$ is a vector of inertial forces and moments; $C(\underline{q})\dot{\underline{q}}^2$ is a vector of centrifugal and Coriolis forces and moments; $\underline{G}(\underline{q})$ is a vector of gravitational forces and moments; $R(\underline{q})$ is a matrix of muscle moment arms; $\underline{F}^M$ is a vector of muscle forces; $R(\underline{q})\,\underline{F}^M$ is a vector of net joint moments; and $\underline{E}(\underline{q}, \dot{\underline{q}})$ is a vector of external forces and moments applied to the body by the environment (8). If the number of joints included in a model of the skeleton is greater than, say, three, a computer is needed to obtain Equation 2 explicitly. Commercial software packages such as SD/FAST (Symbolic Dynamics, Inc., Sunnyvale, California) and ADAMS (Mechanical Dynamics, Inc., Ann Arbor, Michigan) are often used for this purpose.

The system mass matrix, $M(\underline{q})$, has three important properties: First, each entry in $M(\underline{q})$ is a function only of the joint positions, $\underline{q}$; second, the rows and columns of $M(\underline{q})$ are filled with nonzero values, making $M(\underline{q})$ nondiagonal; third, $M(\underline{q})$ is positive-definite (i.e., all of its determinants are greater than zero), and so its inverse, $[M(\underline{q})]^{-1}$, always exists. The latter guarantees that Equation 2 can be solved for the joint accelerations as follows:

$$\ddot{\underline{q}} = [M(\underline{q})]^{-1}\{C(\underline{q})\,\dot{\underline{q}}^2 + \underline{G}(\underline{q}) + R(\underline{q})\,\underline{F}^M + \underline{E}(\underline{q}, \dot{\underline{q}})\}. \tag{3}$$

Because $[M(\underline{q})]^{-1}$ is nondiagonal, the biomechanical system is coupled, and all sources of force—muscle forces, gravitational forces, centrifugal forces, and other external forces acting on the body—contribute to all the joint accelerations according to Equation 3. As shown below, this

simple result has provided some important new insights into leg-muscle function in human locomotion.

LOWER-LIMB MUSCLE FUNCTION IN WALKING AND RUNNING

One of the most striking differences between walking and running is seen in the vertical displacement of the center of mass of the body. The center of mass is highest at midstance in walking and lowest at midstance in running. This difference is reflected in the shapes of the vertical ground reaction forces. The vertical ground reaction force for walking exhibits two distinct peaks, separated by a trough at midstance. As the body vaults over a relatively straight leg at midstance, the downward acceleration of the center of mass increases, causing the vertical ground reaction to dip down. In contrast, the vertical ground reaction force for running has just one peak, whose magnitude is a strong function of running speed. Knee flexion at midstance causes the center of mass to move downward, while the leg muscles act to accelerate the body upward.

The model shown in **Figure 3** was used to study lower-limb muscle function in walking and running (93). Gait experiments were performed on five healthy male subjects (age, 26 $\pm$ 4 years; weight, 70 $\pm$ 5 kg; height, 178 $\pm$ 4 cm). Video motion, force plate, and muscle EMG data were recorded as the subjects walked and ran at the following speeds: slow walk, 0.7 $\pm$ 0.06 m s^{-1}; preferred walk, 1.4 $\pm$ 0.09 m s^{-1}; fast walk, 2.1 $\pm$ 0.05 m s^{-1}; slow run, 2.1 $\pm$ 0.05 m s^{-1}; preferred run, 3.4 $\pm$ 0.2 m s^{-1}. Inverse dynamics was used to calculate the net moments exerted about the back, hip, knee, and ankle joints during the stance phase of gait. The net joint moments were decomposed into individual muscle forces by solving a static-optimization problem that minimized the sum of the squares of the muscle activations (35). Equation 3 was then used in conjunction with a ground reaction force decomposition method (94) to determine the contributions of all muscle forces, gravitational forces, and other external forces (e.g., inertial forces) to the joint angular accelerations and hence to the acceleration of the center of mass.

Muscle Coordination of Walking at the Preferred Speed

The leg muscles fulfill three distinct functions during stance: (*a*) They generate support by opposing the downward pull of gravity, (*b*) they generate progression by accelerating the body forward, and (*c*) they control mediolateral balance in the course of each step. Each of these functions is reflected in the muscles' ability to transmit force to the ground and therefore to accelerate the center of mass of the body in the vertical, fore-aft, and mediolateral directions.

The model calculations suggest that support and forward progression in normal walking are generated mainly by the actions of five muscles: the gluteus maximus, gluteus medius, vasti, soleus, and gastrocnemius (**Figure 4**). Support in the first half of stance is generated by the gluteus maximus, gluteus medius, and vasti, whereas the soleus and gastrocnemius combine to lift and accelerate the center of mass in the second half of stance. Thus the actions of the hip extensors, hip abductors, and knee extensors explain the appearance of the first peak in the vertical ground force in early stance, whereas the ankle plantarflexors are responsible for the appearance of the second peak in late stance. The actions of these muscles also explain the shape of the ground reaction force measured in the fore-aft direction: The vasti decelerates the center of mass in early stance, whereas the soleus and gastrocnemius accelerate it in late stance. These findings are in broad agreement with those obtained by others for walking at the preferred speed (3–5).

The model calculations also show that muscles that lie primarily in the sagittal plane and contribute significantly to support and forward progression also accelerate the center of mass laterally (**Figure 4**). The vasti generates support, decreases the forward speed of the center of

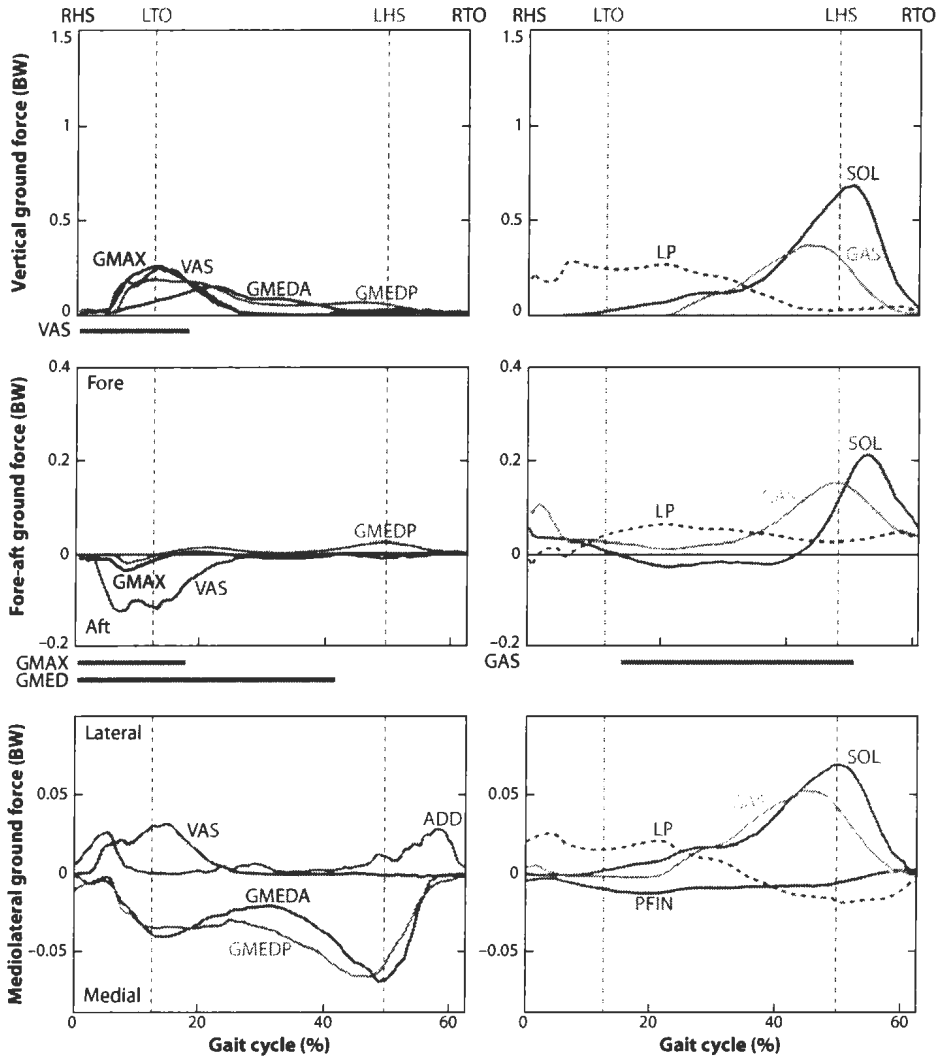

Figure 4

Contributions of individual muscles and limb posture (LP) to the vertical, fore-aft, and mediolateral components of the ground reaction force for walking at the preferred speed of 1.4 m s^{-1}. LP represents the contribution of all gravitational forces to the ground reaction force and describes the resistance to the downward pull of gravity provided by the bones and joints of the stance leg. Results are the mean of the calculated values obtained for five subjects. The shaded regions are the mean vertical, fore-aft, and mediolateral ground reaction forces measured for the same five subjects. Positive ground reaction forces are directed upward, forward, and laterally; negative forces are directed downward, backward, and medially. The horizontal bars indicate mean electromyographic activity measured for some of the leg muscles in five subjects. Symbols defining the major gait events: RHS, heel-strike of the ipsilateral (right) leg; LTO, toe-off of the contralateral (left) leg; LHS, left heel-strike; RTO, right toe-off. Muscle symbols: ADD, adductor magnus, adductor longus, and adductor brevis combined; GAS, medial and lateral portions of gastrocnemius combined; GMAX, medial and lateral portions of gluteus maximus combined; GMEDA and GMEDP, anterior and posterior portions of gluteus medius/minimus, respectively; PFEV, peroneus brevis and peroneus longus combined; PFIN, tibialis posterior, flexor digitorum longus, and flexor hallucis longus combined; SOL, soleus; VAS, vastus medialis, vastus intermedius, and vastus lateralis combined. Adapted from Reference 95.

mass, and accelerates the center of mass laterally during the first half of stance. The anterior and posterior gluteus medius act to oppose the lateral acceleration induced by the vasti (and limb posture) by accelerating the center of mass medially at this time. The soleus and gastrocnemius generate support and forward progression during the second half of stance while accelerating the body laterally. The anterior and posterior gluteus medius actively control balance by accelerating the center of mass medially during the second half of stance.

Although the plantarflexor inverters and everters do not contribute as significantly as the soleus and gastrocnemius contribute to the mediolateral acceleration of the center of mass, their involvement is not negligible. The plantarflexor inverters apply an internal rotation moment about the subtalar joint, which accelerates the subtalar joint internally and the center of mass medially. Similarly, the plantarflexor everters apply an external rotation moment about the subtalar joint, which accelerates the subtalar joint externally and the center of mass laterally. The model calculations suggest, therefore, that the plantarflexor inverters assist the gluteus medius in controlling mediolateral balance during stance.

Does Walking Speed Affect Coordination?

Muscle coordination appears to be invariant to changes in walking speed at speeds higher than the preferred speed; however, significant changes in coordination occur when humans walk more slowly. Peak forces developed by the hip and knee extensors increase as walking speed increases, but the peak forces developed by the ankle plantarflexors remain roughly the same (**Figure 5*a***). Leg-muscle coordination is unchanged, however, as the same five muscles—the gluteus maximus, gluteus medius, vasti, soleus, and gastrocnemius—generate support and forward progression and control mediolateral balance when humans walk faster than the preferred speed (**Figure 5*b***). In contrast, the hip and knee extensors, the gluteus maximus and vasti, play only a minor role in generating support and decelerating the center of mass during the first half of stance at slow walking speeds. Instead, support is generated by the combined effects of gluteus medius muscle action and limb posture [i.e., the resistance to the downward pull of gravity provided by the bones and joints of the stance leg (3, 70)].

Gait Transition

Humans walk at slow speeds and run when they want to move faster. The speed at which humans switch from a walk to a run is approximately the same for most adults ($\sim$2 m s^{-1}). Why do people choose to run at this speed? The answer is not clear, but several possibilities have been discounted, including one that is perhaps the most intuitive: to reduce metabolic energy expenditure. Experiments in which oxygen consumption was recorded for subjects walking and running just below and above the preferred transition speed reveal that running incurs a greater metabolic cost than walking (96). Other factors related to gait kinetics (e.g., the rate at which the ground reaction force is applied to the leg) also have been ruled out (97).

The performance of the ankle plantarflexors in late stance may be one trigger for switching from a walk to a run (98). Gait-analysis measurements performed on 10 subjects showed that the peak vertical and fore-aft ground forces in late stance decreased when subjects walked at and beyond the preferred transition speed. Model simulations also predicted that the forces in all muscles except the soleus and gastrocnemius increased as walking speed increased. The results of **Figure 5*a*** are in accord with these findings. The peak forces developed by the soleus and gastrocnemius remain roughly the same for walking at the preferred speed and faster, indicating that the ability of the plantarflexors to power walking may be compromised at the faster speeds.

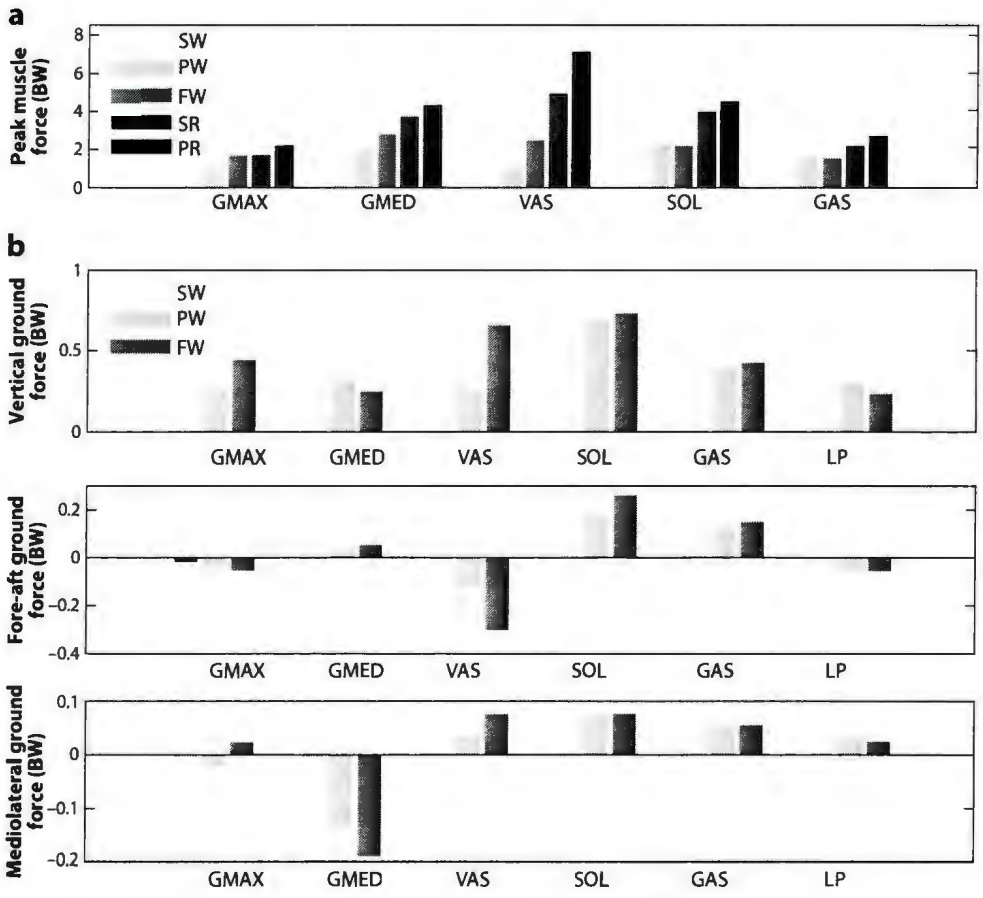

Figure 5

(*a*) Peak forces calculated for selected muscles in walking and running. Results are the mean of the calculated values obtained for five subjects. Abbreviations: SW, slow walk; PW, preferred walk; FW, fast walk; SR, slow run; PR, preferred run. FW and SR were performed at the same speed of 2.1 m s^{-1}, the preferred transition speed. (*b*) Peak contributions of selected muscles and limb posture (LP) to the vertical, fore-aft, and mediolateral ground reaction forces for slow walking (SW, 0.7 m s^{-1}), preferred walking (PW, 1.4 m s^{-1}), and fast walking (FW, 2.1 m s^{-1}). LP represents the contribution of all gravitational forces to the ground reaction force and describes the resistance to the downward pull of gravity provided by the bones and joints of the stance leg. Results are the mean of the calculated values obtained for five subjects. Muscle symbols: GAS, medial and lateral portions of gastrocnemius combined; GMAX, medial and lateral portions of gluteus maximus combined; GMED, anterior and posterior portions of gluteus medius/minimus combined; SOL, soleus; VAS, vastus medialis, vastus intermedius, and vastus lateralis combined. Data from Y-C Lin, M. Jancic, and M.G. Pandy, unpublished analysis.

At the preferred transition speed, the quadriceps and plantarflexors (especially the soleus) develop higher forces in running than in walking (**Figure 5*a***), and this increase in muscle performance arises primarily from an increase in knee flexion during stance. In running, the leg makes contact with the ground in a more erect posture (i.e., the foot is placed closer to the body), allowing the knee to flex a greater amount during stance (**Figure 6*a***). As knee flexion increases, the tibia advances anteriorly, causing an increase in ankle dorsiflexion. The increase in ankle dorsiflexion

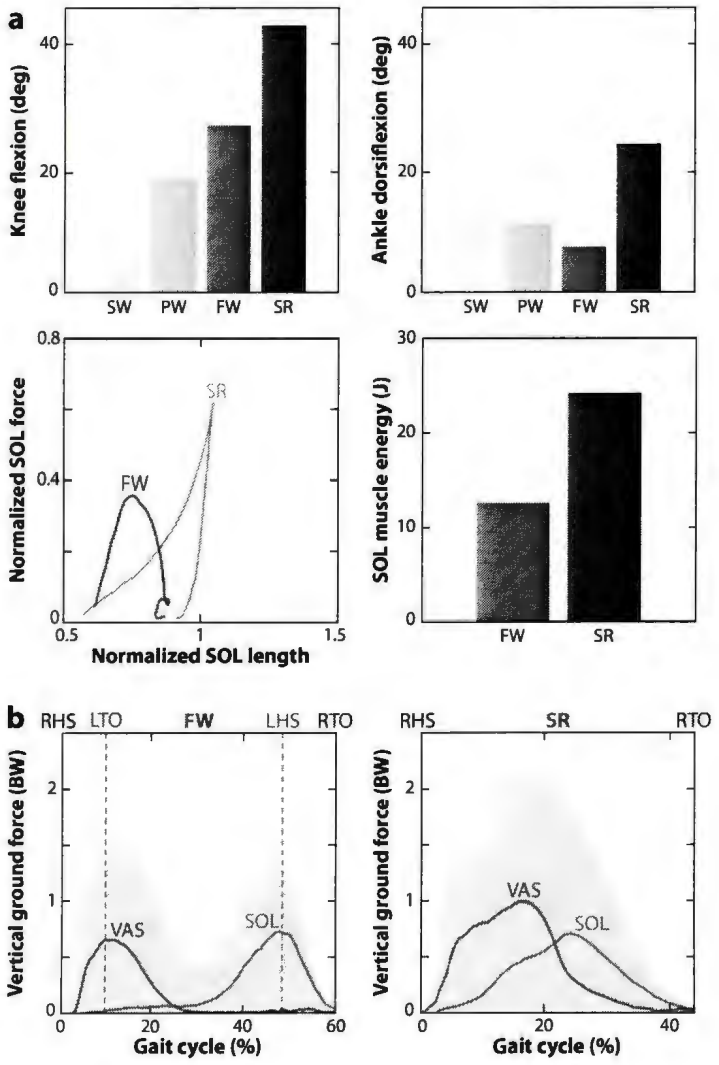

Figure 6

Mechanics of the knee extensors (vasti) and one of the ankle plantarflexors (soleus) for walking and running at the preferred transition speed of 2.1 m s^{-1}. Results are the mean of the calculated values obtained for five subjects. (*a*) *Top row*: Peak knee flexion angles and peak ankle dorsiflexion angles for walking and running at the preferred transition speed (FW and SR, respectively). Also shown are the peak knee and ankle angles for walking at slow and preferred speeds (SW and PW, respectively). Notice the relatively large increases in knee flexion and ankle dorsiflexion when subjects switch from a walk to a run (cf. FW and SR). *Bottom row*: Work done by soleus (SOL) for walking and running at the preferred transition speed (FW and SR, respectively). The diagram on the left shows "work loops" calculated for soleus. Soleus lengthens and develops more force in running than in walking at the transition speed. Therefore, the work done by the muscle (i.e., energy delivered to the skeleton) is greater in running (*right panel*). (*b*) Contributions of vasti (VAS) and soleus (SOL) to the vertical ground reaction force in walking and running at the preferred transition speed (FW and SR, respectively). The shaded regions are the mean vertical ground reaction forces measured for five subjects. Symbols defining the major gait events: RHS, heel-strike of the ipsilateral (right) leg; LTO, toe-off of the contralateral (left) leg; LHS, left heel-strike; RTO, right toe-off. Data from Y-C Lin, M. Jancic, and M.G. Pandy, unpublished analysis.

lengthens the soleus and allows it to operate higher on its force-length curve (i.e., closer to its maximum isometric force). Thus the soleus develops higher forces and delivers more energy to the skeleton in running because of the increase in knee flexion during stance.

Another important difference between walking and running at the transition speed is the phasing of the actions of the knee extensors and ankle plantarflexors during stance. In walking, the vasti and soleus develop forces and deliver energy to the skeleton in early and late stance, respectively, whereas in running, these muscles act in unison to provide a greater upward acceleration of the center of mass in preparation for the subsequent flight phase (**Figure 6*b***). Thus humans may choose to switch from a walk to a run for two interrelated reasons: (*a*) to enhance the biomechanical performance of the ankle plantarflexors, especially the soleus, and (*b*) to better coordinate the actions of the knee extensors and ankle plantarflexors, specifically the vasti and soleus, during stance.

Which Muscles Power Running?

The prime movers in running are the same as those in walking. **Figure 7** shows that the gluteus maximus, gluteus medius, vasti, soleus, and gastrocnemius contribute significantly to support, forward progression, and mediolateral balance in running at the preferred speed. The gluteus maximus, vasti, and soleus generate the majority of support, whereas the gluteus medius, gastrocnemius, and limb posture each contribute less than 0.5 BW throughout stance. The gluteus maximus and gluteus medius accelerate the center of mass forward in the first half of stance; the vasti, soleus, and gastrocnemius slow its forward speed. The soleus and gastrocnemius contribute most significantly to forward acceleration in the second half of stance. In running as in walking, all the prime movers except the gluteus medius accelerate the center of mass laterally during most of the stance phase. The gluteus medius and, to a lesser extent, the plantarflexor inverters control mediolateral balance by accelerating the center of mass medially. Leg-muscle coordination is similar for running at speeds slower than the preferred speed (not shown here; however, see Reference 99 for an analysis of running at the preferred transition speed of $\sim$2 m s^{-1}). No data are available to show how the leg muscles accelerate the center of mass in running at much higher speeds, including maximal sprinting.

HOW MUSCLE ACTION DETERMINES JOINT FUNCTION

Lower-Limb Joint Loading in Walking and Running

The lower-limb joints must withstand high contact forces during daily activities, which render them susceptible to injury and structural deterioration over time. Direct measurements obtained from instrumented joint replacements implanted at the hip and knee show that peak joint contact forces in walking vary with walking speed; they range from 2.8 BW to 4.8 BW at the hip (20) and from 1.9 BW to 2.5 BW at the knee (90). For running at the reasonably fast speed of 5 m s^{-1}, peak contact forces at the hip, knee, and ankle are estimated to be as high as 20 BW, 14 BW, and 12 BW, respectively (100). Joint contact forces are greater in running than in walking because all the forces developed by the prime movers—the gluteus maximus, gluteus medius, vasti, soleus, and gastrocnemius—are much higher (see **Figure 5*a***). As the leg muscles develop forces to power movement, they press the bones together at the hip, knee, and ankle. Thus the forces transmitted by the lower-limb joints result mainly from the actions of the muscles (3, 101). This is an important observation because changes in the functional performance of the lower-limb muscles are thought to influence the pathogenesis of hip and knee osteoarthritis (102–105). Abnormal levels of gluteus medius activity, for example, are often observed in patients with hip osteoarthritis (106).

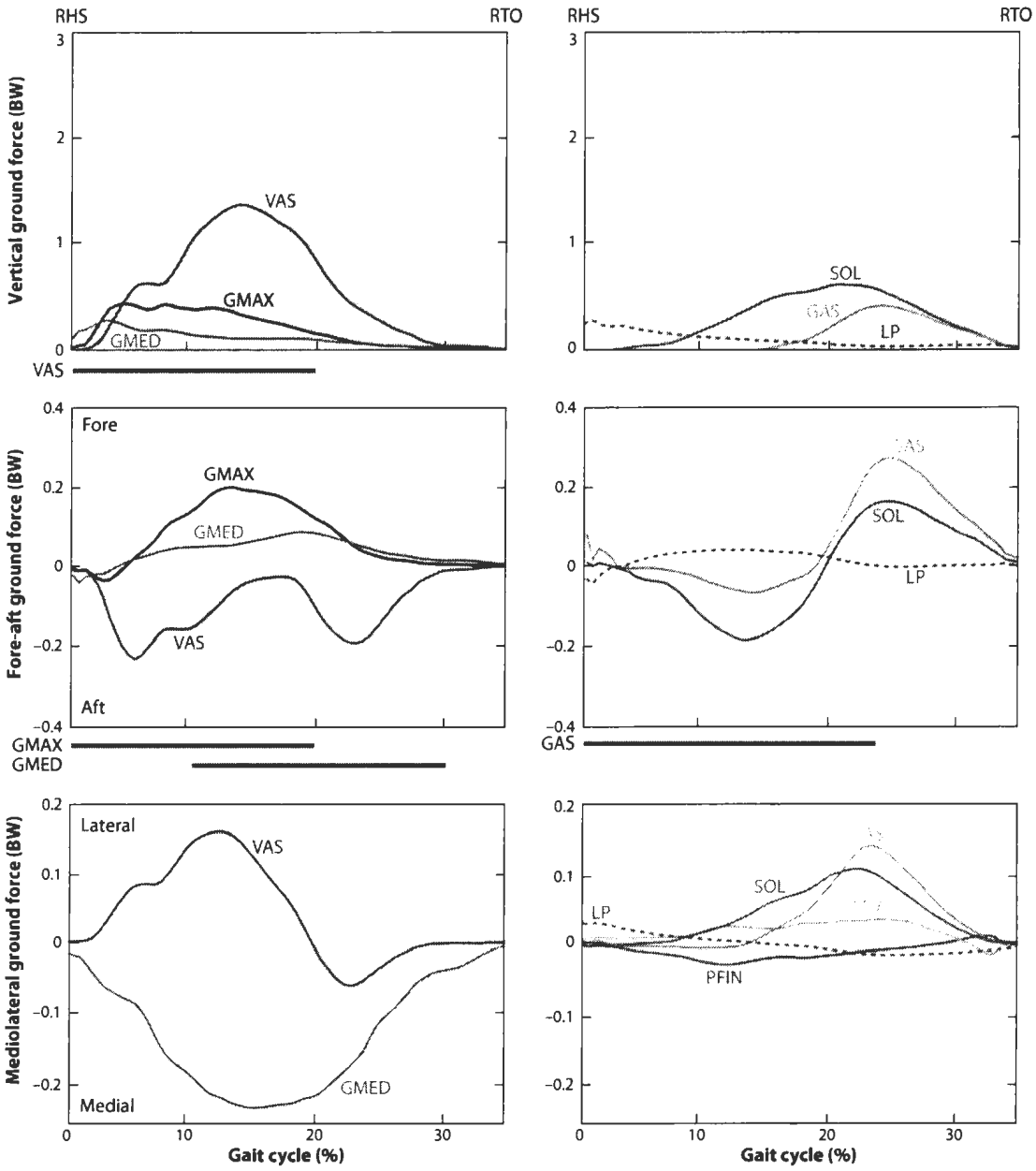

Figure 7

Contributions of selected muscles and limb posture (LP) to the vertical, fore-aft, and mediolateral ground reaction forces for running at the preferred speed of 3.4 m s^{-1}. LP represents the contribution of all gravitational forces to the ground reaction force and describes the resistance to the downward pull of gravity provided by the bones and joints of the stance leg. Results are the mean of the calculated values obtained for five subjects. The shaded regions are the mean vertical, fore-aft, and mediolateral ground reaction forces measured for the same five subjects. Positive ground reaction forces are directed upward, forward, and laterally; negative forces are directed downward, backward, and medially. The horizontal bars indicate mean electromyographic activity measured for some of the leg muscles in five subjects. Symbols defining the major gait events: RHS, heel-strike of the ipsilateral (right) leg; RTO, right toe-off. Muscle symbols are defined in the captions associated with **Figures 4** and **5**. Data from Y-C Lin, M. Jancic, and M.G. Pandy, unpublished analysis.

Figure 8 shows how the individual leg muscles contribute to the contact forces acting at the hip, knee, and ankle for walking and running at the preferred speeds. In walking, the peak compressive forces calculated at the hip and knee are 4.0 BW and 2.5 BW, respectively, which agree closely with measurements recorded from instrumented implants (**Figure 8**, PW). Muscles contribute up to 95% of the compressive force acting at the hip in normal walking, and the ligaments, gravitational forces (limb posture), and centrifugal forces (i.e., forces arising from motion of the joints) account for the remainder (107). Five hip-spanning muscles—the gluteus medius, gluteus maximus, iliopsoas, rectus femoris, and hamstrings—contribute most significantly to the hip contact force (**Figure 8**, PW). The first peak at contralateral toe-off results mainly from the actions of the gluteus medius, gluteus maximus, and rectus femoris, whereas the second peak at contralateral heel-strike results from the forces developed by the gluteus medius, iliopsoas, and rectus femoris. The smaller peak in the hip contact force visible immediately after heel-strike arises from the action of the hamstrings.

The compressive force at the knee also exhibits two peaks: one at contralateral toe-off and the other at contralateral heel-strike (**Figure 8**, PW). The first peak is caused mainly by the action of the quadriceps, particularly the vasti, which generates support in the first half of stance. The second peak results almost entirely from the force developed by the gastrocnemius, which lifts and accelerates the body forward in the second half of stance (3, 44, 69). The hamstrings also contribute significantly to the knee contact force, but only in early stance, before contralateral toe-off. The peak contact force at the ankle occurs at contralateral heel-strike and results mainly from the actions of the soleus and gastrocnemius (**Figure 8**, PW).

Five hip-spanning muscles—the gluteus medius, gluteus maximus, iliopsoas, rectus femoris, and hamstrings—also contribute significantly to the compressive force acting at the hip in running (**Figure 8**, PR). The gluteus medius, gluteus maximus, and rectus femoris combine to produce the major peak at midstance, whereas the hamstrings and iliopsoas contribute to lesser extents. In running as in walking, the compressive force acting at the knee is dominated by the actions of three knee-spanning muscles: the vasti, rectus femoris, and gastrocnemius.

Muscles that do not span a joint can contribute to the contact force acting at that joint. This is a consequence of the coupling that exists between muscle forces and joint motion (see Equation 3), which causes each muscle force to be transmitted to all the body joints simultaneously. The calculations show that the uniarticular knee extensor, the vasti, contributes to the contact force acting at the ankle in running, whereas the uniarticular ankle plantarflexor, the soleus, contributes to the contact force at the knee in both walking and running (**Figure 8**). However, these effects are small (less than 1 BW) compared with the compressive forces applied by the muscles spanning each joint.

Muscle-Ligament Interactions at the Knee

The knee is the most intensely studied joint, presumably because it is the most frequently affected by injury and disease, but also perhaps because it is anatomically and functionally the most challenging to understand. The incongruent articulating surfaces of the femur and tibia mean that knee stability is wholly dependent on the actions of the muscles and ligaments. The forces transmitted to the knee ligaments are determined by the balance of forces created by muscle action, contact between the leg and the ground, and compression of the articular surfaces of the bones. Despite the rather extensive literature on knee-joint biomechanics, the complex interactions of these forces in the intact knee are not fully comprehended, and certainly there is only a limited understanding of the roles that they may play in injury and disease (108).

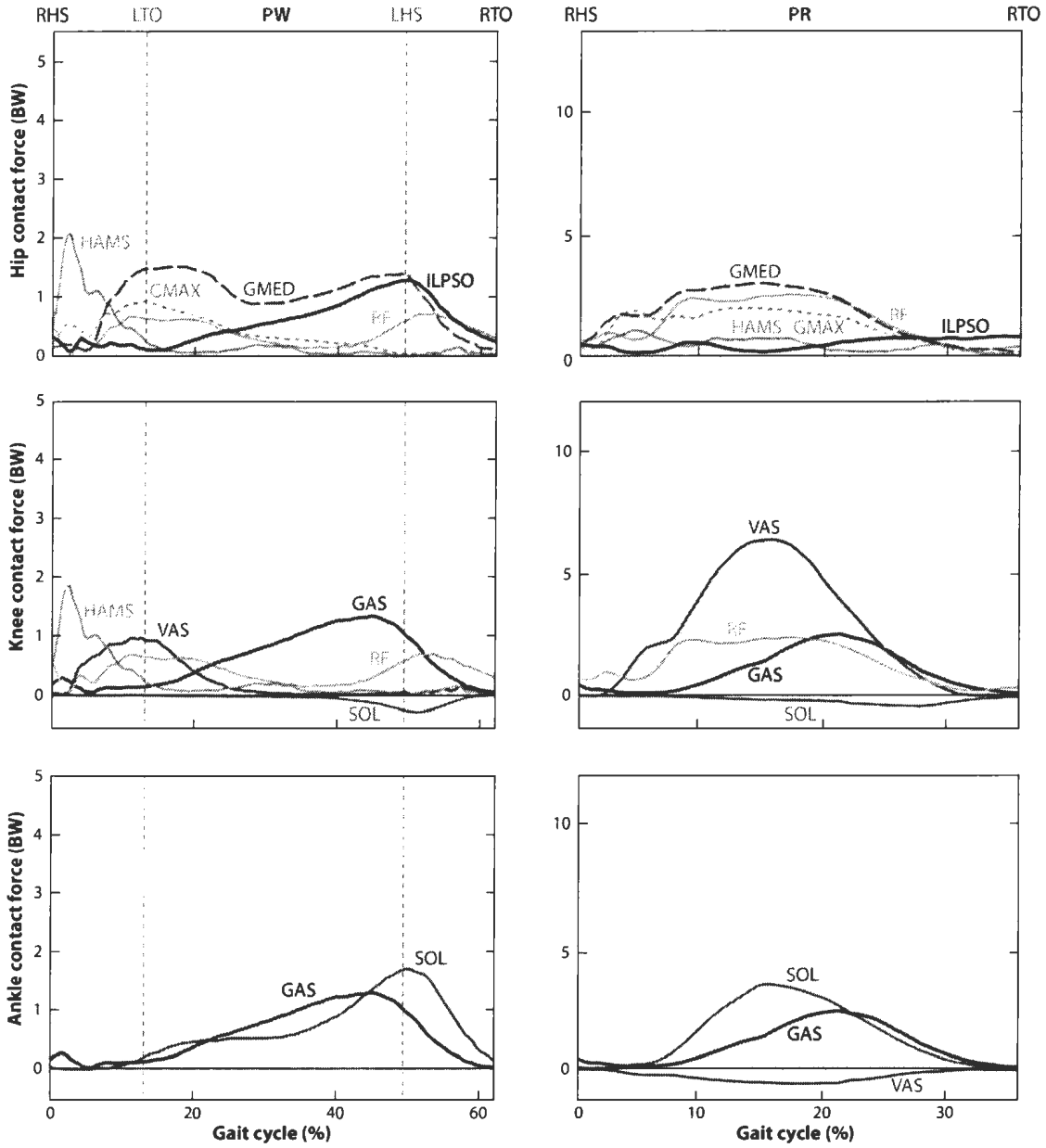

Figure 8

Contributions of selected muscles to the resultant contact forces acting at the hip, knee, and ankle for walking at the preferred speed of 1.4 m s^{-1} (PW) and for running at the preferred speed of 3.4 m s^{-1} (PR). The shaded regions are the mean compressive forces acting at the hip, knee, and ankle joints. Results are the mean of the calculated values obtained for five subjects. Symbols defining the major gait events: RHS, heel-strike of the ipsilateral (right) leg; LTO, toe-off of the contralateral (left) leg; LHS, left heel-strike; RTO, right toe-off. Muscle symbols: GAS, medial and lateral portions of gastrocnemius combined; GMAX, medial and lateral portions of gluteus maximus combined; GMED, anterior and posterior portions of gluteus medius/minimus combined; HAMS, semimembranosus, semitendinosus, and biceps femoris long head combined; ILPSO, iliacus and psoas major combined; RF, rectus femoris; SOL, soleus; VAS, vastus medialis, vastus intermedius, and vastus lateralis combined. Data from Y-C Lin and M.G. Pandy, unpublished analysis.

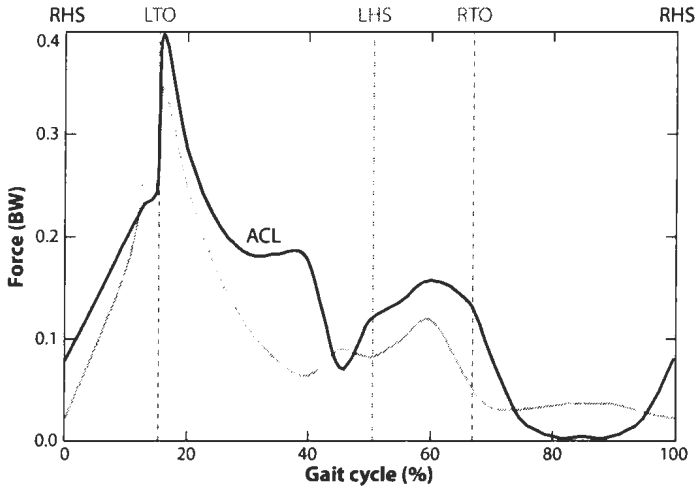

Figure 9

Shear force applied by the quadriceps via the patellar tendon (PT) to the lower leg and the resulting force transmitted to the anterior cruciate ligament (ACL) in walking at the preferred speed. Positive shear forces are directed anteriorly. Reproduced from Reference 111.

In vivo measurements of knee-ligament strains have been reported for commonly prescribed rehabilitation exercises such as active knee extension, sit-to-stand, and stepping up and down (109). Although these data have been useful in defining the strains incurred in the knee ligaments during dynamic activity, the results do not explain the interactions that occur between the muscles, ligaments, and articulating surfaces of the bones. Mathematical modeling overcomes the limitations of experiments performed on cadavers and living subjects and has yielded valuable insights into the function of the knee ligaments during activities such as walking (110–112).

Model simulations of normal walking show that the ACL is loaded throughout stance (**Figure 9**). Peak force is transmitted to the ligament at contralateral toe-off and is estimated to be 0.4 BW, well below its failure strength (~2.9 BW for young adults) (113). In the remainder of stance, ACL force is roughly one-half the amount borne by the ligament at contralateral toe-off, and even smaller during swing. The calculations also suggest that the pattern of ACL force in walking is explained by the behavior of the quadriceps (mainly the vasti) in stance. Peak ACL force results from a peak in the knee extensor moment at contralateral toe-off, which in turn is caused by a peak force developed by the quadriceps. The pattern of ACL loading closely resembles the pattern of shear force applied to the tibia by the quadriceps via the patellar tendon. Whereas other muscles crossing the knee, specifically the gastrocnemius and hamstrings, in addition to the ground reaction force, play a large role in determining ACL loading during the second half of stance, the quadriceps dominates ACL force in the first half of stance (111).

A peak ACL force of 0.4 BW in normal walking is not unexpected because the maximum force developed by the quadriceps is estimated to be ~1.4 BW, whereas the maximum shear force applied to the tibia is four times less (~0.35 BW) (111). The force transmitted to the ACL is therefore equal to the applied shear force divided by the cosine of the angle between the ACL and the tibial plateau, which is close to 1 (114). Peak quadriceps force is much higher in running (see **Figure 5*a***); however, its influence on ACL strain is mitigated by the fact that the shear force applied by the quadriceps to the tibia is reduced, as the patellar-tendon insertion angle is reduced

when the knee is more flexed during running. No data are available on the forces borne by the knee ligaments in running.

The Knee Adduction Moment

In walking and running, the resultant ground reaction force is directed toward the body's center of mass and remains medial to the hip and knee for all but the beginning of stance. The vertical and mediolateral components of the ground reaction force can be resolved into another force that acts only in the frontal plane, and this force creates a moment about the knee, the adduction moment (115, 116), which tends to turn the leg inward. Thus the magnitude of the knee adduction moment is determined by the magnitudes of the vertical and mediolateral components of the ground reaction force; these two components define the orientation of the ground reaction in the frontal plane and, consequently, the distance of this force vector from the knee (117, 118).

As shown in **Figure 4**, the vertical and mediolateral components of the ground reaction force in walking arise mainly from the actions of five muscles: the gluteus maximus, gluteus medius, vasti, soleus, and gastrocnemius. That the knee adduction moment is determined by the magnitudes of the vertical and mediolateral components of the ground reaction force implies that these five muscles also must contribute to the adduction moment. **Figure 10** was obtained by taking each muscle's contributions to the vertical and mediolateral components of the ground reaction force, calculating the resultant contribution of the muscle to the portion of the ground reaction force

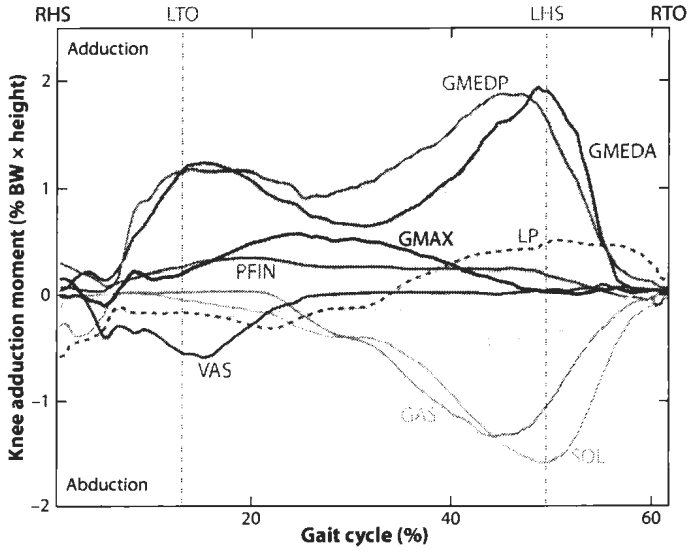

Figure 10

Contributions of selected muscles and limb posture (LP) to the knee adduction moment for walking at the preferred speed of 1.4 m s^{-1}. The shaded region is the mean knee adduction moment calculated from experimental gait data recorded for five subjects. All other results are the mean of the calculated values obtained for the same five subjects. LP represents the contribution of all gravitational forces to the ground reaction force and describes the resistance to the downward pull of gravity provided by the bones and joints of the stance leg. Symbols defining the major gait events: RHS, heel-strike of the ipsilateral (right) leg; LTO, toe-off of the contralateral (left) leg; LHS, left heel-strike; RTO, right toe-off. Muscle symbols are defined in the captions for **Figures 4** and **8**. Data from Y-C Lin and M.G. Pandy, unpublished analysis.

that acts in the frontal plane, and then multiplying the magnitude of this resultant force vector by the distance between its line of action in the frontal plane and the center of the knee joint. The results show how the individual leg muscles and gravitational forces (limb posture) create the adduction moment at the knee in normal walking. How the leg muscles and knee ligaments act to balance the adduction moment and stabilize the knee in the frontal plane is discussed in the next section (see Knee Stability in the Frontal Plane, below).

The calculations confirm that muscles that do not span the knee, such as the gluteus medius and soleus, contribute significantly to the knee adduction moment. Furthermore, whereas some muscles act, by virtue of the ground reaction force, to turn the leg inward and adduct the knee (e.g., gluteus medius and gluteus maximus), others act to the turn the leg outward and abduct the knee (e.g., soleus and gastrocnemius). Gravitational forces (limb posture) induce an abduction moment during the first half of stance and an adduction moment thereafter.

The hip and ankle muscles may be important in determining the magnitude of the knee adduction moment and, therefore, the force transmitted by the medial compartment in walking (102, 103, 105, 116, 119). There is some disagreement, however, over whether the hip abductor muscles act to increase or reduce the knee adduction moment (120). The results of **Figure 10** show that the hip abductors, the anterior and posterior gluteus medius, contribute significantly to the first peak in the knee adduction moment at contralateral toe-off. Recall from **Figures 4** and **5** that these muscles are also responsible for controlling mediolateral balance in walking. A decrease in gluteus medius force would reduce the muscle's contributions to the vertical and mediolateral components of the ground reaction force and hence the knee adduction moment. This may explain the significant decrease in knee adduction moment seen in subjects who walk with a lateral trunk lean, as these subjects use less hip abductor muscle force by moving their centers of mass closer to the stance-leg hip (121).

Increasing the foot progression angle during walking, commonly referred to as toeing-out, also has been found to lower the knee adduction moment in late stance; a decrease in ankle inversion moment is thought to be the cause (116, 122). **Figure 10** shows that the ankle plantarflexor inverters contribute substantially to the knee adduction moment throughout stance. If toeing-out decreases the force developed by the plantarflexor inverters, and hence the inversion moment exerted about the ankle, then the results of **Figure 10** explain how the knee adduction moment may be reduced by walking in this manner. However, the more significant effect of toe-out in late stance may be an increase in ankle plantarflexor muscle force. **Figure 10** indicates that the soleus and gastrocnemius induce relatively large abduction moments about the knee in late stance. If walking with the feet splayed slightly outward increases the forces in these muscles, it also will lower the adduction moment at the knee. No data have been reported to show how ankle plantarflexor muscle moments during late stance are affected by toe-out walking.

Knee Stability in the Frontal Plane

As the ground reaction force tends to adduct the leg inward, it presses the femur and tibia together on the medial side of the knee. Some combination of muscle and ligament action is then needed to equilibrate the ground force and prevent the articulating surfaces from separating on the lateral side.

A model similar to that shown in **Figure 3** was used to determine the combination of muscle and ligament forces needed to resist the adduction moment (i.e., provide an equal and opposite abduction moment) and stabilize the knee in the frontal plane during normal walking (69). Vasti

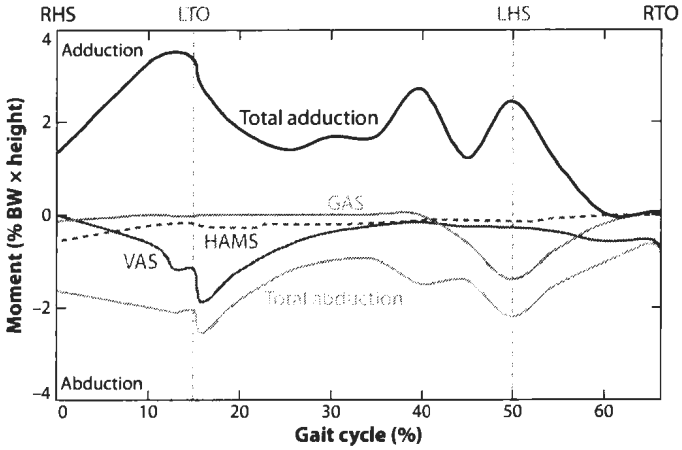

Figure 11

Resistance to the external knee adduction moment provided by the muscles crossing the knee. The external knee adduction moment is the moment of the ground reaction force acting about the center of the knee in the frontal plane. The external adduction moment (total adduction, *purple line*) was obtained from a dynamic-optimization simulation of normal walking in which muscle forces were calculated by minimizing metabolic energy (43). Note that this result is quantitatively different from that shown in **Figure 10**, which was derived from experimental gait data. Also shown is the total knee abduction moment (*blue line*), which was obtained by summing the moments produced by the component of the ground reaction force in the frontal plane and the lateral compartment tibiofemoral force acting about the center of pressure in the medial compartment. Vasti and gastrocnemius contribute most significantly to knee stability in the frontal plane by resisting the external knee adduction moment. Abbreviations are defined in previous figure captions. Reproduced from Reference 69.

and gastrocnemius muscle action provides the necessary resistance to the knee adduction moment: The vasti contributes most significantly to the first peak in the stabilizing abduction moment, whereas the second peak is determined mainly by the action of the gastrocnemius (**Figure 11**). The hamstrings contribute significantly immediately after heel-strike and before the foot is placed flat on the ground, but tensor fascia latae, sartorius, and gracilis contribute very little. The calculations also indicate that the ligaments of the posterior lateral corner provide the primary passive resistance to knee adduction in early stance and midstance (not shown in **Figure 11**; however, see figure 3 in Reference 69). A recent study (123) reported results similar to those shown in **Figure 11**, although the hamstrings and tensor fascia latae were found to contribute more significantly to a stabilizing knee abduction moment. The latter analysis did not take into account the separate contributions made by the ligaments in resisting the adduction moment, which may explain why larger contributions were needed from these muscles to stabilize the knee on the lateral side in the absence of the ligaments of the posterior lateral corner.

Given the orientation of the ground reaction force in the frontal plane, one would expect most of the compressive force between the femur and tibia to be transmitted by the medial compartment. This contention is supported not only by the results of modeling studies (48, 69, 118, 123) but also by the findings of a recent experiment in which contact force was measured directly in a patient fitted with an instrumented knee implant (124). These studies agree that the lower limit of force transmitted by the medial compartment occurs during early and late stance, when the total contact force at the knee is shared nearly equally between the two compartments. There is some

debate, however, with respect to the upper limit of load transmitted by the medial compartment. The instrumented implant experiments suggest that the muscles and collateral ligaments prevent separation of the implant surfaces in the lateral compartment, whereas the model calculations predict lateral condylar liftoff for brief periods of the stance phase (69, 118). This difference between the model predictions and experimental results may arise from differences between the shapes of the articulating surfaces of the implant components and those of the intact knee on which the calculations are based and/or from differences between the gait patterns of healthy subjects and those of total knee replacement patients.

SUMMARY POINTS

1. Muscle and joint function in human gait can be determined when the following information is available: (*a*) accurate measurements of ground reaction forces, (*b*) accurate measurements of body-segmental motion, and (*c*) accurate knowledge of muscle and joint contact loading.
2. The accuracy of muscle-force estimates is determined, in part, by the values of the parameters assumed in a model of movement. Muscle-force estimates are most sensitive to changes in tendon rest lengths and muscle-fiber lengths. New methods are needed for accurate measurement of muscle, tendon, ligament, cartilage, and bone tissue properties in vivo.
3. Whether a subject-specific model is needed for accurate evaluation of muscle and joint function depends on the purpose of the model. Subject-specific models are needed in surgical planning and clinical decision making, as well as in studies of joint function. If the purpose is to study muscle coordination of gait in able-bodied persons, then scaled-generic models may suffice.
4. Model predictions of muscle and joint contact forces cannot be validated by noninvasive measurements. Model response may be evaluated by simulating an in vitro experiment in which muscle and joint loading can be measured directly. The validated model then can be used to study function under physiological loading conditions.
5. Five muscles—the gluteus maximus, gluteus medius, vasti, soleus, and gastrocnemius—contribute most significantly to the accelerations of the center of mass in the vertical, fore-aft, and mediolateral directions when humans walk at the preferred speed. Muscle coordination is invariant to changes in walking speed at speeds higher than the preferred speed. At slower walking speeds, support is generated by the combined effects of gluteus medius muscle action and limb posture (i.e., the resistance to the downward pull of gravity provided by the bones and joints of the stance leg).
6. Humans choose to switch from a walk to a run for two interrelated reasons: (*a*) to enhance the biomechanical performance of the ankle plantarflexors, especially the soleus, and (*b*) to better coordinate the actions of the vasti and soleus during stance.
7. The prime movers in running are the same as those in walking. The gluteus maximus, gluteus medius, vasti, soleus, and gastrocnemius contribute significantly to support and forward progression in running at the preferred speed. The gluteus medius and, to a lesser extent, the plantarflexor inverters control mediolateral balance.

8. Muscles that do not span a joint can contribute to the contact force transmitted by that joint and therefore affect its stability. In walking, for example, uniarticular muscles that cross the hip and ankle act to create the adduction moment at the knee, thereby contributing to the contact force present in the medial compartment.

FUTURE ISSUES

Better methods for measuring, modeling, simulating, and analyzing movement will lead to a more advanced understanding of muscle and joint function in human locomotion. Areas in which future work ought to be directed include:

- Developing efficient computational algorithms for automatically segmenting and reconstructing magnetic resonance images of muscles, ligaments, cartilage, and bones.
- Coupling accurate measurements of joint motion obtained from biplane X-ray fluoroscopy with forward-dynamics simulations to determine muscle and joint loading in gait, with the caveat that motion constraints associated with fluoroscopic motion capture may not reflect natural patterns of movement.
- Developing new noninvasive imaging methods to obtain accurate subject-specific measurements of the architectural and material properties of muscle, tendon, ligament, cartilage, and bone tissue in vivo.
- Developing more accurate analytical methods for scaling generic computer models of the human musculoskeletal system.
- Developing hybrid optimization and EMG-driven models to obtain more accurate estimates of muscle and joint contact forces in gait.
- Developing new experimental tools to validate model predictions of in vivo muscle and joint contact loading.
- Developing parametric algorithms that account for the ranges of intra- and intersubject variations often observed in patterns of locomotion.
- Performing analyses of muscle and joint function across the full spectrum of locomotion speeds, including maximal sprinting.

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