UNIVERSITY OF CALGARY

Economic Evaluation of an Injury Prevention Strategy in High School Basketball

by

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A THESIS

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Abstract

Objective: To examine the resource use and cost impact of high school basketball injuries in Calgary and area high school basketball players and to determine the cost of a balance training program in preventing injury in this population.

Design: Economic Evaluation in conjunction with a Cluster-Randomized Controlled Trial.

Main Outcome Measures: Mean cost per player by treatment arm; mean cost of injury in individuals suffering an injury, by treatment arm; cost to prevent one injury in a Calgary and area high school basketball player.

Results: The mean cost per player and mean cost of injury were significantly greater for the intervention group than the control group. The cost of preventing one injury is $2000.40.

Conclusions: The current practice for injury prevention in high school basketball (i.e. the status quo) was less expensive and marginally as effective as the balance training program. Further investigation to address poor compliance to the program is required.

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Finally, I would like to thank my friends who, while they may not have understood my decision to return to school, completely supported me throughout these two busy and intense years.

Dedication

This thesis is dedicated to my parents, Leon and Helen McAllister. Their unconditional support has allowed me to return to my academic pursuits, their encouragement enables me to keep going and their pride motivates me to strive for excellence.

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Chapter One: INTRODUCTION

Basketball is one of the most popular sports today with more than 400 million participants worldwide (Fédération International de Basketball, n.d.) and just under one million participants in Canada (M. Dottori, personal communication, April 13, 2006). In Alberta, basketball is popular in the adolescent population. Survey results from southern Alberta (Emery, Meeuwisse, and McAllister, 2006) identify basketball as the sport with the top participation rate for both male & female high school students.

Unfortunately, basketball is also a sport with a high rate of injury. Emery et al. (2006) identify basketball as the sport with the highest proportion (12%) of injuries reported by surveyed high school students in Alberta. In another study, 19% of the sport injury events charted over a six year period in a rural emergency department were a result of basketball participation (Prebble, et al., 1999). Fifty-three percent of the basketball injuries occurred at school and 90% of those occurred during organized school activity such as team practices, interscholastic competition or physical education class. A systematic review of prospective studies examining injury rates in adolescent basketball reported injury rates ranging from 28 to 86 injuries/100 players/season (Harmer, 2005).

1.1 Impact of Sport Injury

Although most sport injuries are not life threatening, the occurrence of sport injury can result in pain, disability and/or dysfunction in the short-term, long-term and even permanently. Sport injury may also coincide with the potential for increased susceptibility to future injury and/or the development of osteoarthritis. Felson (2003) indicates previous major injury to a joint as the most common local factor to dramatically increase risk for osteoarthritis. The knee is reported as the most commonly affected joint (Drawer, and Fuller, 2001; Felson, 2003; Kujala, Orava, Parkkari, Kaprio, and Sarna, 2003; Roos, 2005) although Koh and Dietz (2005) acknowledge that the knee is not the only joint susceptible to osteoarthritis following sport injury and that all major peripheral joints are vulnerable to this condition. Injuries sustained when athletes are young adults may affect them for the rest of their lives (Roos, 2005). Joint injuries, especially those to weight bearing joints such as the knee and ankle, have been shown to have increased risk of developing (and earlier occurrence) osteoarthritis as compared to those without injury (Lohmander, Ostenberg, Englund, and Roos, H., 2004; Roos, E., 2005; von Porat, Roos, E., and Roos, H., 2004).

1.2 Sport Injury Prevention

Despite research to support the significance of sport injury on the future health of young athletes, injury has historically been overlooked as a health issue. This is due, in part, to the belief that injuries are accidents that cannot be anticipated or prevented (SMARTRISK, 2005). Fortunately, there is research to indicate otherwise; however, currently there is no standard of care for evidence based injury prevention strategies in the adolescent amateur athlete population. Balance has been a focus of sport injury prevention research to date. Balance training alone and more comprehensive neuromuscular training programs that include a balance training component have been shown to reduce the incidence of injury in sports such as European handball (Myklebust, Engebretsen, Braekken, Skjolberg, Olsen, and Bahr, 2003), volleyball (Verhagen, van der Beek, Twisk, Bouter, Bahr, and van Mechelen, 2004) and soccer (Tropp, Askling, and Gillquist, 1985). These studies primarily examine elite adult athlete populations, where the public health impact is limited. Studies investigating balance and neuromuscular training programs in adolescent populations have also been shown to reduce the incidence of injury in basketball (McGuine, and Keene, 2006), soccer (Mandelbaum et al., 2005), European handball (Olsen, Myklebust, Engebretsen, Holme, and Bahr, 2005; Wedderkopp, Kaltoft, Holm, and Froberg, 2003; Wedderkopp, Kaltoft, Lundgaard, Rosendahl, and Froberg, 1999) and high school physical education students (Emery, Cassidy, Klassen, and Rosychuk, 2005a).

1.3 Health Care Impact

The health and economic benefits of sport participation are abundant. However, the research on sport injury suggests that the risk of short-term and long-term health consequences could decrease or potentially negate the economic savings of physical health from sport participation (Felson, 2003; McGuine, and Keene, 2006; Roos, 2005). Policy decisions are often ultimately influenced by economics – money talks. The data on Canadian health care resource use and subsequent cost from sport injury is lacking, as most cost of injury studies performed by the regional, provincial and national governments have not collected data on sport injury as a separate mechanism until recently but rather as 'other', or 'unintentional'. The economic burden of unintentional injury in Canada is estimated at $8.7 billion and at $1.8 billion in Alberta (SMARTRISK, 2005). The rate of emergency department visits in Alberta due to sport injury in 15 to 19 year olds is estimated at 4044.93 visits per 100,000 persons (Child Health Surveillance Project Data Group, 2005). Further research on the cost of sport injury in Canada could provide some useful data for the consideration of economic evaluation of possible interventions.

Although sport injury will not be eliminated, the development of evidence-based prevention strategies to reduce both the incidence and severity of sport injury in adolescents is important to the sport participant, parent, health care provider, insurers and the public health system. A targeted injury prevention strategy for adolescent basketball players has been developed to address the high rate of injury in this popular sport. The program seeks to reduce injury in the most cost-effective manner possible to gain the attention of the provincial health care insurance plan in Alberta for future program implementation.

1.4 Purpose of the Study

As a sport with both high participation and high injury rates in the North American adolescent population, high school basketball should be a priority for sport injury prevention research.

The purpose of this study was to identify the resources and costs associated with a sport injury prevention program in Calgary and area high school basketball players and to calculate the cost of such a program in preventing specific injuries. This would be the first study to investigate the economic impact of sport injury in high school sports in Alberta and the only known study to investigate the cost to prevent sport injuries in an adolescent population with a specific intervention in a randomized controlled trial (RCT).

1.5 Summary of Thesis Format

This thesis will first present a review of the literature pertaining to economic analysis of a sport injury prevention strategy (Chapter Two), followed by a summary of RCT methods and detailed information regarding the economic evaluation methods in Chapter Three. A summary of RCT results and detailed results of the economic evaluation are presented in Chapter Four. A discussion of the results and recommendations for future research are included in the final chapter (Chapter Five).

Chapter Two: LITERATURE REVIEW

2.1 Introduction

Policy makers have encountered large increases in healthcare expenditures as a result of many new medical procedures and interventions - with the increased burden on health care systems and extended health insurance, there is a growing interest in information on the additional costs and benefits of these interventions (van Hout, Al, Gordon, and Rutten, 1994). For research in medical interventions, the randomized controlled trial (RCT) is the gold standard for experimental design. Historically, economic evaluation in conjunction with RCTs was not commonplace with the exception of RCTs in the pharmaceutical industry.

Investigations regarding the economic benefits of physical activity and sport are found in the literature since the 1980's, although not necessarily associated with an RCT design. Studies with a variety of methodological designs to evaluate the cost of sport injuries have also been published in the last two decades (de Loees, 1990; Forssblad, Weidenhielm, and Werner, 2005; Gabbett, 2001; Garrick & Requa, 1993; van Beeck, van Roijen, and Mackenbach, 1997). However, to date, there are a limited number of published prospective, randomized studies in the area of sport injury prevention. Even more limited are published economic evaluations in the field of sport injury prevention. With overburdened health care budgets and insurance companies seeking to reduce costs, the adage that an ounce of prevention is worth a pound of cure is no longer sufficient to stimulate or justify implementation of prevention strategies into the public health model. It has been suggested there is a need for quality research examining the economics of preventing injury rather than simply the economics of injury once it has occurred. (Currie, Dymond Kerfoot, Donaldson, and Macarthur, 2000).

2.2 Objective

The objective of this research is to investigate the cost-effectiveness of a wobble board training program in reducing injury rates in high school basketball players through a comprehensive economic evaluation. A review of the literature was completed to determine if any sport injury prevention strategies have been deemed to be cost-effective or cost-beneficial. Cost-effectiveness studies involve comparison of at least two health care options with the same goal and generally report the outcome as a measure of cost per natural unit of health effect whereas cost-benefit analyses look at several competing projects and a comparison of the costs of the options against the benefits, expressed in monetary terms, is undertaken (Donaldson, and Shackley, 1997).

The investigation of past research methodologies and outcomes related to economic evaluations of injury prevention strategies should provide opportunity for future improvements and innovations to be implemented.

2.3 Data sources

A computerized database search was performed. The databases of MEDLINE (1966-2005), Nursing & Allied Health (CINAHL 1982-2005) and Allied and Complimentary Medicine (AMED 1985-2005) were accessed to identify articles potentially relevant to the economics of sport injury prevention. The Medical Subject Heading (MeSH) of “athletic injuries” and/or the keywords of “sports injuries” or “injury prevention” was combined with MeSH of “economics”, “costs and cost analysis”, “cost and cost benefit” and/or keywords of “cost effectiveness”, “economic evaluation” or “cost” in these searches. No limitations were put on articles searched under these Medical Subject Headings or keywords. The study title and abstract were reviewed to identify potentially relevant articles. Complete articles with potential relevance were obtained and reviewed briefly to ultimately determine inclusion in the literature review.

A similar search strategy was completed in the databases of Sport Discus, Physical Education Index, EconLit and PAIS International. Key words of “cost-effectiveness”, “cost-benefit”, “injury prevention”, “cost”, “cost of injury”, and “sport injury” were utilized in these searches and the same strategy for article relevance was followed as with the OVID databases.

2.4 Study Selection

A study was identified as potentially relevant by review of the study title and abstract. Currie et al. (2000) discuss the contribution of health economics to injury research. The authors indicate that the estimation of effectiveness, costs and benefits associated with injury prevention interventions rather than evaluations of cost of injury are more useful for health care decision making and resource allocation. As such, economic evaluations of sport injury without an associated injury prevention intervention were not included in this review.

Inclusion criteria for the review of literature were as follows:

1) Epidemiological study examining a sport injury prevention strategy in a human population
2) The investigation included an evaluation of the costs of such a strategy in reducing injury
3) Study design included a comparison group
4) English language study

2.5 Results

There were a total of four articles that met the inclusion criteria for this literature review. Publications that included an economic evaluation of a sport injury prevention intervention are noted in Table 1.

Table 1: Studies of economics of sport injury prevention

Authors	Year	Study Design	Intervention Details
Verhagen et al.	2005	Prospective cost-effectiveness analysis alongside a RCT.	Wobble board program in reducing ankle sprains in elite volleyball players.
Quarrie et al.	2005	Ecological	Mouth guard use and dental injuries in rugby.
Olmsted et al.	2004	Retrospective, utilizing previously published ankle taping and/or bracing studies.	Ankle taping and/or ankle bracing in reducing ankle sprains.
Janda et al.	1990	Prospective cost assessment in a study with no control group.	Break-away bases in preventing recreational softball injuries.

Research design and methods for economic evaluation were significantly variable among the four studies. Only one study evaluated the cost-effectiveness of a prevention strategy alongside an RCT. Verhagen, van Tulder, van der Beek, Bouter, and van Mechelen (2005) examined the cost-effectiveness of a wobble board training program in elite adult volleyball players. This study was the most similar in design to the RCT in our study and was one of only two prospective economic evaluations of sport injury prevention found in the literature searches. Methods for economic evaluation alongside this RCT are as follows.

The cost measures were tracked with cost diaries provided to all athletes who suffered an ankle sprain as a result of volleyball. Mean direct, indirect and total costs were calculated and compared between the intervention and control groups. Effectiveness measures were based on the number needed to treat (NNT) to prevent one ankle sprain. NNT is the number of patients needed to treat with the experimental rather than the control treatment to prevent one patient developing the adverse outcome (Petrie, and Sabin, 2005, p.148). In this study, NNT was calculated using the ankle sprain risk difference value, representing the difference in ankle sprain incidence per 1000 hours. The risk difference was then divided into 1 to provide the NNT value, as per the following formula.

$$NNT = 1 / \text{Risk Difference}$$

Of note, NNT is traditionally calculated from the absolute arithmetic difference in occurrences of adverse outcomes between groups (Culyer, 2005, p. 2) rather than from incidence rate differences. The authors do not provide rationale for this methodology discrepancy. An adjustment to the NNT was required to represent the mean individual exposure of 97.43 hours. The cost of preventing one ankle sprain was then determined by multiplying the adjusted NNT by the mean difference in total costs per player in the total population. This value was calculated at €444.03 ($626.35 CAD January 9, 2006 Bank of Canada nominal rate). Sensitivity analyses were performed on the data, targeting individuals with a previous history of ankle sprain. The time horizon for this economic evaluation was 36 weeks, the same as the intervention program itself, although individual costs were only tracked for the time period that the athlete was unable to participate in the sport. This may not have allowed for all of the utilized health care resources to be accounted for.

Another study utilizing NNT to evaluate a sport injury prevention strategy was a retrospective cost-benefit analysis of prophylactic ankle taping and bracing (Olmsted, Vela, Denegar, and Hertel, 2004). The authors accumulated published research articles on the effectiveness of prophylactic ankle taping and/or ankle bracing in reducing ankle sprains. Studies were sought from publications on PubMed, CINAHL, SPORT Discus and PEDro between 1966 and 2002. Reference lists of the resulting articles were also reviewed to identify additional studies. A critical appraisal scale was incorporated to assess quality of the studies. Ultimately, three articles met their inclusion criteria and a NNT for athletes with and without a history of ankle sprain in each qualifying study was calculated.

Subsequently, a cost-benefit analysis was performed, using the assumption that the preventative effects of the interventions were the same for all three study populations. Numerous assumptions were made to determine taping and bracing costs. Costs for taping did not include the salary of the athletic trainer who provided the tape job, and did not include other normally utilized taping supply costs such as prewrap, tape adherent, heel and lace pads or skin lubricant. The rationale for the exclusion of these costs was not provided. Ultimately, cost per ankle sprain was estimated by multiplying the cost of the specific intervention by the NNT and total cost per season was estimated by multiplying the number of interventions per season by cost per ankle sprain. This value does not represent any of the medical costs associated with an ankle sprain but rather the intervention costs to prevent the sprain. With the authors definition in mind, bracing for a season was more cost-beneficial (of note, the term was used interchangeably with cost-effective) than taping for a season. Different study populations, intervention materials, intervention time frames, overall study designs and lack of control groups challenge the internal validity of this study.

The only other prospective economic evaluation in the literature to meet the inclusion criteria for this review was a three-phase analysis of prevention of recreational softball injuries, specifically through the comparison of break-away bases and standard stationary bases (Janda, Wojtys, Hankin, Benedict, and Hensinger, 1990). There was no control group in this trial as teams were assigned to various playing fields with or without break-away bases on a random and rotating basis. Injuries were grouped by field of play rather than by individual or group. Although not explicitly described, it appears that costs for these injuries were determined from reports of local hospital emergency rooms, the Student Health Service and private practice orthopaedic surgeons who were all requested to keep logs of patients if they were injured on the study fields. If all injured athletes attended these facilities and/or practitioners exclusively and obtained no outside medical care, the calculated costs would likely be quite accurate. The likelihood of this may be questionable and the expression of total medical charges does not provide the reader with any insight into what costs were actually assessed, nor the time horizon for the cost assessment. Additionally, no analysis of cost versus effect or benefit was addressed. The economic evaluation was to present the total medical charges for all injuries sustained on the intervention fields versus the total medical charges for all injuries sustained on the standard base fields. In addition to a lack of a control group, there was no tracking of exposure or risk all of which are important elements to an analysis of medical intervention.

The final study meeting the inclusion criteria for this review was a uniquely designed study to investigate the effects of compulsory mouth guard usage on dental injury claims for New Zealand rugby players (Quarrie, Gianotti, Chalmers, and Hopkins, 2005). Information on rugby related dental injury claims was obtained from ACC, the administrator of the New Zealand's accident compensation scheme for the period of 1995-2003. Data regarding mouth guard use was obtained from three separate studies that surveyed mouth guard wearing rates before 1993 and in 2002 and 2003 respectively.

An average dental injury claim to ACC was reported as $321 (NZD). Based on the assumption that the dental injury claim rate would have remained constant without the implementation of mandatory mouth guard use, the authors used the average cost of a dental injury claim and the cumulative number of claims "saved" to calculate a cumulative savings in claims costs for the study period of $1.87 million (NZD). In this study, the economic evaluation again appeared to be a cost assessment, as no analysis of cost versus effect or benefit was directly addressed. Additionally, no information regarding the costs of mouthguards, or the implementation, administration or regulation of their use was reported. The authors state that mandating mouth guard use in New Zealand rugby has coincided with a 43% reduction in dental injury claims. Numerous limitations were noted in the study, including lack of accurate player data, assumed rates of mouth guard wearing from survey studies with varied methodologies and populations, and no information on type of mouth guards worn. Ecological studies cannot establish cause and effect and the information provided in this study was presented as both compelling evidence and coincidence.

2.6 Discussion

It is difficult to compare four studies with such diverse methodologies. Each study acknowledged limitations in design and results and the majority of these studies are not considered to have undertaken full economic evaluations of their respective interventions. The NNT analysis may be appropriate for determining the effectiveness measure for a cost-effectiveness evaluation as it is easier to interpret than odds ratios and relative risks (Cook, and Sackett, 1995) and allows for a clinically relevant interpretation for prevention outcomes. Collection of costs ranged from self-completed cost diaries, to review of insurance files, to an estimation of supply costs. One study compared the cost-effectiveness of an intervention against no intervention, whereas one study compared the cost-benefit of two different interventions in three previously completed studies, all without control groups. The study by Janda et al. (1990)

reported on the total costs of injuries incurred while playing on fields with the intervention and the total costs of injuries incurred while playing on fields without the intervention but could not directly assess the cost-effectiveness of the injury prevention strategies. Despite this limitation, a conclusion was reached that "the extra cost for a set of break-away bases is far outweighed by the potential savings in health care costs is using one intervention or not using the intervention" (p. 634). Three of the four studies evaluated only one injury outcome (such as an ankle sprain or a dental injury) whereas one study included all injuries. Two of the studies performed sensitivity analyses for individuals with a previous history of injury.

Only one study actually assessed the original objective of whether any sport injury prevention strategies have been deemed cost-effective or cost-beneficial. Verhagen et al. (2005) determined that the cost of preventing one ankle sprain with their intervention was approximately €444.03 and estimated that the cost of preventing one ankle sprain in a previously injured player was approximately €51.68. Olmsted et al. (2005) did conclude that ankle bracing was more cost-beneficial than ankle taping over the course of a season but there was no specific control group on which to base an economic decision and the health care costs associated with treating the injuries were not reported. Relevance of the economic evaluation measures in the long term versus short term was noted by both Verhagen et al. and Olmstead et al.

With minimal published literature on economic evaluations of sport injury prevention strategies available, there was a need to seek out methodological guidelines for such an investigation. Numerous documents have been published on economic evaluation guidelines, although the majority of these are directed to pharmaceutical trials. The Canadian Agency for Drugs and Technologies in Health (CADTH, formerly the Canadian Coordinating Office for Health Technology Assessment) recently published the 3rd edition of *Guidelines for the Economic Evaluation of Health Technologies: Canada* (formerly *Guidelines for the Economic Evaluation of Pharmaceuticals: Canada*). The previous editions of the document were primarily directed to pharmaceutical trials but the revision has expanded to address the information needs of a broader audience (page iv). Health technology assessment is the process of systematically reviewing existing evidence and providing an evaluation of the effectiveness, cost-effectiveness and impact, both on patient health and on the health care system, of medical technology and its use (International Network of Agencies for Health Technology Assessment, n.d.). CADTH's definition of health technologies includes drugs, devices, medical and surgical procedures and health systems used in the maintenance, restoration and promotion of health (p. iv).

These guidelines provide a useful template for the economic evaluation of a sport injury prevention strategy in a randomized controlled trial. Although not all elements of the guidelines are applicable, the relevant / transferable elements can be adapted and utilized as a main resource for the economic evaluation of a wobble board training program in reducing injury in high school basketball players.

2.7 Conclusion

Acknowledgement is given to the importance of considering economic evaluations in many health research undertakings. The inclusions of such data in the sport injury prevention realm are not well established, nor are the methods of doing so. Ultimately, in the current literature there is no common standard of practice for performing economic evaluations with sport injury prevention investigations. This is certainly an unexplored area for health economics. As such, the CADTH guidance document is a suitable template for such an evaluation.

Chapter Three: METHODS

The economic evaluation was completed in conjunction with the cluster randomized controlled trial of Emery, Rose, McAllister, and Meeuwisse (in press). An outline of the RCT details and methods is presented below as an important adjunct to the economic evaluation methods.

3.1 Randomized Controlled Trial (RCT)

3.1.1 Study Design and Subjects

The study was a cluster RCT. The study population was Calgary and area high school basketball players. Inclusion criteria for the study were male and female adolescents between the ages of 12 and 18 that were enrolled in a Public or Separate School Board high school in Calgary and surrounding area, and were a member of their respective interscholastic basketball team. Exclusion criteria for the study were an injury within six weeks prior to the study commencement which prevented full participation in basketball at the start of the high school basketball season, a history of systemic disease (i.e. cancer, arthritis, heart disease), or neurological disorder (i.e. head injury, cerebral palsy). Parental consent (or participant consent if 18 years of age) was required to participate in the study. Ethics approval was received from the Calgary and area School Boards and the Office of Biomedical Ethics at the University of Calgary.

3.1.2 Methods

Once consent to participate was provided, the team therapist completed baseline measurements of height, weight, functional strength via vertical jump (Petschnig, Baron, and Albrecht, 1998) fitness via 20m shuttle run, Canadian version (Leger, and Gadoury, 1989; Leger, Mercier, Gadoury, and Lambert, 1988; McNaughton, Cooley, Kearney, and Smith, 1996) and balance via single-leg, eyes closed testing on a foam pad (Emery, Cassidy, Klassen, Rosychuk, and Rowe, 2005b) of all participating players. Participating players were also asked to complete a pre-season questionnaire relating to medical/injury history and sport participation. Data was collected on each consenting athlete in regards to participation in team training sessions and games throughout the entire season. This information was recorded on a daily basis on a weekly exposure sheet (WES) by a team designate. The WES was adapted from an injury surveillance program (Canadian Intercollegiate Sport Injury Registry) that was developed, implemented and validated by the Sport Epidemiology Research Group at the University of Calgary (Meeuwisse, and Love, 1997).

3.1.2.1 Blinding

Team therapists were blinded to treatment arm allocation. The instruction of the intervention program was provided to each intervention school by a physiotherapist or Certified Athletic Therapist that was not the team therapist assigned to that particular school.

3.1.2.2 Injury Definition and Tracking

Injuries meeting the criteria of: *an injury occurring during basketball (game, practice or dryland training activity) which required medical attention and/or resulted in the inability to complete the session of activity in which the injury occurred and/or required the athlete to miss at least one day of sporting activity* were flagged by the coach and/or team designate and these injuries were subsequently reported on an Injury Report Form (IRF). The study physiotherapist or Certified Athletic Therapist assigned to the school visited the teams on a weekly basis and was notified of all injuries and IRFs. Injuries were assessed by the assigned study therapist and the IRF, including the therapist assessment component, was completed. This IRF was standardized across all teams to ensure consistency of information. All injury records were reviewed by the research coordinator to ensure they met the injury criteria prior to inclusion in the database.

3.1.2.3 Data Management

Data from the baseline measurements, preseason questionnaires, IRFs, and WES forms were entered into a Microsoft® Excel™ spreadsheet over the duration of the study. Data entry was reviewed by the primary investigator and research coordinators for accuracy and missing data. Where necessary, clarifications regarding injury information were obtained by follow up phone calls with the players and/or parent/guardian.

Compliance forms (see Appendix A) to record adherence to the wobble board training home program were provided at the start of the season. Follow-up phone calls or school visits to collect this data were performed by the research coordinator.

3.1.3 Intervention Overview

Both arms of the RCT were provided with the same sport-specific warm-up program and asked to complete this prior to each training session and game. This 10 minute warm-up included aerobic, static stretch, and dynamic stretch components. This was considered the current standard of practice for a high school basketball warm-up routine.

There were two portions of the intervention program in this study; both portions were designed to utilize a wobble board. A wobble board is a circular platform that sits atop a half-sphere and is designed to develop, improve and/or restore balance. Presently, wobble boards or other similar proprioceptive devices (e.g. foam pads, air cells, perturbation machines) are used in physical rehabilitation and some elite level conditioning programs. They can also be used to improve range of motion in the ankle and foot.

The retail unit cost of the wobble board utilized in this RCT (Fitter®first® Classic Balance Board) at the time of the study was $39.95(CAD). Numerous other brands are available across the province and country and prices may range from approximately $20.00 to $60.00. Essentially, the variation in the wobble boards may be in the material used to produce the board (plastic versus wood) and the ability to adjust the height of the wobble board (and hence the difficulty). There is no published data on utilization patterns of wobble boards in high school athletes, as this trial was the only trial of its kind in Canada known to the study investigators.

3.1.3.1 Sport-specific Component

The team-based wobble board program for the school setting was a 5 minute program that incorporated sport specific activities into the balance training and was to be completed as part of the warm-up session at every practice. This included basketball passing, stationary dribbling and person to person contact while balancing on the wobble board, as shown in Appendix B. The sport-specific team based wobble board training component was similar to the training program of Mykelbust et al. (2003), who demonstrated a reduction in anterior cruciate ligament (ACL) injury in elite handball players following a multifaceted neuromuscular training program that included a sport-specific balance training component. This program was pre-tested at two Dinos Development Camps in the summer of 2004.

3.1.3.2 Home Program Component

Individuals in the intervention group were also asked to perform a daily 20 minute program at home using the wobble board they were provided. This program was six weeks in duration and was progressive in nature, commencing with eyes open and bipedal tasks and gradually moving to unipedal and/or eyes closed tasks, as shown in Appendix C. Players were asked to continue the balance program on a weekly basis once the formal six week program was completed. The specific details of the intervention program are included in Appendix D. The home program balance training exercises for this RCT were from Emery, Cassidy, Klassen, Rosychuk, and Rowe (2005a), who demonstrated a reduction in overall sports injury in adolescents following a six week home-based balance training program. The home program balance training exercises of Emery et al. (2005a) were adapted from Hoffman and Payne (1995), who designed a program to demonstrate the effectiveness of proprioceptive ankle disk training on increasing unipedal balance of healthy subjects, and Wester, Jesperson, Nielsen, and Neumann (1996), who designed a program for post-injury ankle sprain rehabilitation which was effective in the reduction of recurrent ankle sprain and residual symptoms.

3.1.4 Treatment Comparator

There was no treatment comparator in this study as no current standard of care for injury prevention exists in this population. As such, the control group was considered as the status quo.

3.2 ECONOMIC EVALUATION

The purpose of this study was to identify from the viewpoint of (a) the public payer and (b) the provincial health care system, what resources and costs are associated with a sport injury prevention program in high school basketball players and to determine the cost of such a program in preventing specific injuries.

3.2.1 Target audience and perspective

This evaluation is presented with primary consideration of the public payer perspective. Direct health care costs that were incurred as a result of a basketball injury sustained within the 2004-2005 high school basketball season were collected along with costs of the intervention itself. A decision not to include indirect costs (i.e. productivity, travel time) in this evaluation was made due to the lack of tracking all appropriate costs in the RCT design and also with the rationale that resource use due to adolescent time loss from sport is not well developed and may be of limited impact.

Secondary consideration, and hence analysis to reflect such information, is given to the provincial health care insurance plan (provided by Alberta Health and Wellness [AHW]). It should be noted that certain costs considered in the primary analysis may not be carried by the provincial health care system. The exclusionary costs may include injury rehabilitation services, bracing materials, splints, slings, and/or crutches. These costs are still a resultant burden of injury and are relevant to the primary audience; however, a secondary analysis to present the costs of injury and cost to prevent injury that would be borne directly by the provincial health care insurance plan was considered important for this potential target funder.

3.2.2 Methods

Data collection for this economic evaluation started concurrently with a cluster RCT that investigated the effectiveness of a wobble board training program in reducing injury rates in high school basketball players residing in and around Calgary. No assessment of health-related quality of life (i.e. utility score) was utilized in this evaluation.

3.2.2.1 Outcome measures

The main outcome measurement in this study was the mean cost per player by treatment arm. Secondary outcome measurements include the mean cost of injury by treatment arm and the cost of preventing one injury, using number needed to treat (NNT) to avoid one injury values.

3.2.2.2 Time Horizon

The time horizon for this economic evaluation is 12 months from the commencement of the RCT. This equates to November 22, 2004 through November 22, 2005. This time horizon was chosen as a reasonable representation of ongoing treatment schedules for the more serious injuries such as ACL tears. Based on ongoing follow-up with these players, there were no known costs to be incurred beyond the end of the time horizon. Long-term costs such as those associated with increased risk of future injury or of osteoarthritis are not included in this evaluation.

3.2.2.3 Discounting

Discounting was not performed in the evaluation due to the brevity of the intervention and its related costs. The Guidelines for the Economic Evaluation of Health Technologies: Canada document indicates that discounting is necessary for costs and outcomes that occur beyond one year (Canadian Agency for Drugs and Technologies in Health, 2006). The intervention itself was six weeks in duration and the time horizon was 12 months. The majority of injury costs in this RCT were borne immediately and in a relatively small time frame.

3.2.2.4 Costing

The costing of health care interventions consists of three steps: the identification of resources, the measurement of resource use and cost valuation (Baladi, 1996). A micro-costing approach was used in this evaluation, although broader estimates had to be applied in the case of hospital ambulatory care visits and day surgeries. Micro-costing is based on the description of detailed resources used by an individual patient on an item by item basis (CADTH, 2006, p. A-14).

Resource Identification and Measurement

The identification and measurement of resources utilized as a result of a basketball injury within the context of this study were collected prospectively on the IRF. The IRF contained two sections on resource use, one specific to visits to health care professionals and one specific to supplies, equipment and procedures. Each section had selection boxes beside a specifically identified intervention to distinguish what services and supplies had been used and how many times this occurred. Each section included the opportunity to identify services, supplies or procedures not already listed on the form. The noted sections are included on the IRF in Appendix E. All economic data from the IRFs were entered into a Microsoft® Excel™ spreadsheet. Where clarification on resource use was necessary, the player was contacted directly.

Cost Valuation

Cost valuation for direct health care resources such as physician consultations and visits was based on the Alberta Health Care Insurance Plan Medical Price List (October 2004 schedule). The appropriate codes and fees for these visits were obtained with the assistance of a physician and billing coordinator. Surgical procedure codes and subsequent costs were determined by consultation with relevant experts, specifically an orthopaedic surgeon, surgical assistant, anaesthetist, billing clerks, and applicable hospital personnel. Surgical cost valuations, exclusive of the fee-for-service portions, were obtained from Quality, Safety & Health Information of the Calgary Health Region.

Cost valuations for services determined as external to the publicly funded health care system were estimated from provincial/national regulatory bodies billing guidelines as available and were based on 2004/2005 pricing. Cost valuations of supplies and equipment determined as external to the publicly funded health care system were sought directly from the injured athlete where possible. Where these costs were unavailable, expert consultation was sought for identification of the most common brand and/or style of each category of equipment and supplies.

Some key assumptions were made for the pricing determination of individual injury costs. Wherever specific details on services, procedures, supplies or equipment were not available, expert consultation was utilized to best estimate this information. A detailed account of cost valuation methods for all medical and paramedical visits and materials is included in Appendix F. Cost valuation methods for the intervention program are included in Appendix G.

Research based costs (i.e. study therapist payroll and travel claims) were excluded from the cost analysis. Additionally, the Goods and Services Tax (GST) was not included in the cost evaluation as this was considered a transfer cost.

3.2.2.5 Outcome Values

Costs were totalled at the individual level and then summed by treatment arm. The mean cost per player per treatment arm was calculated from the total cost per treatment arm, inclusive of the total intervention costs, divided by the number of individuals in each respective arm. The mean cost of injury by treatment arm was calculated from the total cost per treatment arm, excluding the intervention costs, divided by the number of injuries in each respective arm. The cost of preventing one injury, one lower extremity injury, one ankle sprain and one acute injury were determined by multiplying the respective NNT by the respective mean difference in total costs for each above noted category. NNT is the number of patients needed to treat with the experimental rather than the control treatment to prevent one patient developing the adverse outcome (Petrie, and Sabin, 2005, p.148). NNT for overall injury, lower extremity injury, ankle sprain injury and acute injury were each determined by calculation of the absolute risk reduction (ARR) values, representing the difference in injury rate between the control group and the intervention group in each respective injury category. The NNT is estimated based on the reciprocal of the ARR, as per the following formula.

$$NNT = 1 / ARR$$

Minimum and maximum range estimates for the cost to prevent one injury were calculated using the confidence limits of the NNT values and the difference in mean cost estimates between the intervention and control groups.

All outcome measures were recalculated with costs designated as those borne solely by AHW using the same methods as described above. The assumptions for the cost designations are presented in Appendix F.

3.2.2.6 Variability

Stratification analyses by gender and sensitivity analyses by area of injury (i.e. lower extremity and ankle) and mechanism of injury (i.e. acute) for the primary and secondary outcome measures were considered. These subgroups and injury types were selected to parallel the RCT investigation and were considered as potential sources of variability in the evaluation.

3.2.2.7 Uncertainty

Cost valuation is a source of uncertainty in the evaluation, particularly where average costs were used for a resource that had a range of costs presented. To deal with the multiple cost variables, an analysis of extremes was performed on the primary outcome measure to present potential best and worst case scenarios. The highest and lowest fees that were collected for physiotherapy, athletic therapy, chiropractic and massage therapy services as well as braces, surgery, emergency department visits and the intervention itself were substituted into the model.

Analysis of extremes for the cost per injury prevented outcomes was performed by using the mean difference in total cost per player of the worst case scenario with the upper confidence limit of NNT and the mean difference in total cost per player of the best case scenario with the lower confidence limit of NNT.

The range of values for the variables that were utilized in the analysis of extremes is presented in Appendix H. The NNT confidence limits are presented in Table 2.

3.2.2.8 Analysis

Intercooled Stata®, versions 8.2 and 9.1 (Stata Corporation, 2005) was used for the statistical analysis of the RCT economic data. Confidence intervals (95%) are presented for all applicable outcomes. Statistical significances of the differences in outcome measures between groups are presented as *p*-values and were calculated from *t*-tests of two sample means. In the case of failure to meet the assumptions of normality, non-parametric methods are used to estimate 95% confidence intervals and compare the cost outcomes (bootstrapping techniques).

Chapter Four: RESULTS

4.1 Randomized Controlled Trial

4.1.1 Player Participation

There were 920 Calgary and area high school basketball players that participated in the Randomized Controlled Trial (RCT). A flow chart of study enrolment is included in Appendix I.

4.1.2 Baseline Characteristics

Data was collected on players at the beginning of the season through preseason questionnaires and physical measures to assess risk homogeneity between groups. There were no clinically relevant differences in the baseline characteristics between the control and intervention groups. Baseline characteristics are included in Appendix J.

4.1.3 Adverse Events

No adverse events were reported as a result of participating in the intervention program.

4.1.4 Injury Outcomes

There were a total of 271 injuries sustained by 225 players throughout the basketball season. One hundred eighty four players sustained one injury, 36 players sustained two injuries and five players sustained three injuries.

Comparison of injury rates between study groups were based on an intent-to-treat strategy. When considering all injuries sustained in the RCT, there were a total of 141 injuries in the control group (injury rate = 33.1 injuries per 100 players [95%CI; 28.64-37.79]). In the intervention group there were a total of 130 injuries (injury rate = 26.32 injuries per 100 players [95%CI; 22.48-30.43]). Further details regarding overall injury rates and Number Needed to Treat (NNT) by gender are shown in Table 2.

Table 2: Injury Rates and NNT by Treatment Arm and Gender

Treatment Arm (Gender)	Number of athletes	Number of injuries	Injury Rate (95% Confidence Interval)	NNT (95% CI)
Control (All)	426	141	33.10 (28.64-37.79)	
Intervention (All)	494	130	26.32 (22.48-30.43)	15 (8-130)
Control (Male)	220	64	29.09 (23.18-35.57)	
Intervention (Male)	244	47	19.26 (14.51-24.78)	11 (6-49)
Control (Female)	206	77	37.38 (30.75-44.37)	
Intervention (Female)	250	83	33.2 (27.39-39.41)	24 (8-n/a*)

*n/a=implausible value related to a negative 95% CI lower limit for Absolute Risk Reduction (ARR)

Injury rates for all injury, based on exposure were 4.03 injuries per 1000 player hours for the control group (95%CI; 3.4-4.76) and 3.3 injuries per 1000 player hours for the intervention group (95%CI; 2.76-3.92). Based on univariate analysis, unadjusted for cluster randomization, the relative risk of injury in the intervention group compared to the control group was 0.82 (95%CI; 0.64–1.05). Further details regarding overall exposure-based injury rates and relative risk are shown in Table 3.

Table 3: Exposure-based Injury Rates and Relative Risk by Treatment Arm and Gender

Treatment Arm (Gender)	Hours	Injuries	Injuries/1000 player hours (95% CI)	Relative Risk (95% CI)	Stat. Sig.*
Control (All)	34955	141	4.03 (3.4-4.76)	1	
Intervention (All)	39369	130	3.3 (2.76-3.92)	0.82 (0.64-1.05)	*p*=.10
Control (Male)	19476	64	3.29 (2.53-4.19)	1	
Intervention (Male)	19777	47	2.38 (1.75-3.16)	0.72 (0.49-1.07)	*p*=.09
Control (Female)	15479	77	4.98 (3.93-6.21)	1	
Intervention (Female)	19592	83	4.24 (3.38-5.25)	0.85 (0.62-1.18)	*p*=.31

* Statistical significance

Lower Extremity Injuries

When considering lower extremity injuries sustained in the RCT, there were a total of 111 lower extremity injuries in the control group (injury rate = 26.06 lower extremity injuries per 100 players [95%CI; 21.95-30.5]). In the intervention group there were a total of 106 lower extremity injuries (injury rate = 21.46 lower extremity injuries per 100 players [95%CI; 17.92-25.34]). Further details regarding lower extremity injury rates and NNT are shown in Table 4.

Table 4: Lower Extremity Injury Rates and NNT by Treatment Arm

Treatment Arm	Number of athletes	Number of injuries	Injury Rate (95% Confidence Interval)	NNT (95% CI)
Control	426	111	26.06 (21.95-30.50)	
Intervention	494	106	21.46 (17.92-25.34)	22 (10-n/a*)

*n/a=implausible value related to a negative 95% CI lower limit for ARR

Lower extremity injury rates based on exposure were 3.18 injuries per 1000 player hours for the control group (95%CI; 2.61–3.82) and 2.69 injuries per 1000 player hours for the intervention group (95%CI; 2.2–3.26). Based on univariate analysis, unadjusted for cluster randomization, the relative risk of lower extremity injury in the intervention group compared to the control group was 0.85 (95%CI; 0.64–1.12). Further details regarding exposure-based lower extremity injury rates and relative risk are shown in Table 5.

Table 5: Exposure-based Lower Extremity Injury Rates and Relative Risk by Treatment Arm

Treatment Arm	Hours	Injuries	Injuries/1000 player hours (95% CI)	Relative Risk (95% CI)	Stat. Sig.*
Control	34955	111	3.18 (2.61-3.82)	1	
Intervention	39369	106	2.69 (2.2-3.26)	0.85 (0.64-1.12)	*p*=.23

*Statistical significance

Ankle Sprain Injuries

When considering ankle sprain injuries sustained in the RCT, there were a total of 76 ankle sprains in the control group (injury rate = 17.84 ankle sprains per 100 players [95%CI; 14.32-21.81]). In the intervention group there were a total of 62 ankle sprains (injury rate = 12.55 ankle sprains per 100 players [95%CI; 9.76-15.80]). Further details regarding ankle sprain injury rates and NNT are shown in Table 6.

Table 6: Ankle Sprain Injury Rates and NNT by Treatment Arm

Treatment Arm	Number of athletes	Number of injuries	Injury Rate (95% Confidence Interval)	NNT
Control	426	76	17.84 (14.32-21.81)	
Intervention	494	62	12.55 (9.76-15.80)	19 (11-160)

Ankle sprain injury rates based on exposure were 2.17 injuries per 1000 player hours for the control group (95%CI; 1.71–2.72) and 1.58 injuries per 1000 player hours for the intervention group (95%CI; 1.21–2.02). Based on univariate analysis, unadjusted for cluster randomization, the relative risk of injury in the intervention group compared to the control group was 0.72 (95%CI; 0.51–1.03). Further details regarding exposure-based ankle sprain injury rates and relative risk are shown in Table 7.

Table 7: Exposure-based Ankle Sprain Injury Rates and Relative Risk by Treatment Arm

Treatment Arm	Hours	Injuries	Injuries/1000 player hours (95% CI)	Relative Risk (95% CI)	Stat. Sig.*
Control	34955	76	2.17 (1.71-2.72)	1	
Intervention	39369	62	1.58 (1.21-2.02)	0.72 (0.51-1.03)	p=.06

*Statistical significance

Acute Injuries

When considering acute injuries sustained in the RCT, there were a total of 134 acute injuries in the control group (injury rate = 31.46 injuries per 100 players [95% CI; 27.07-36.1]). In the intervention group there were a total of 109 acute injuries (injury rate = 22.06 injuries per 100 players [95%CI; 18.48-25.98]). Further details regarding acute injury rates and NNT are shown in Table 8.

Table 8: Acute Injury Rates and NNT by Treatment Arm

Treatment Arm	Number of athletes	Number of injuries	Injury Rate (95% Confidence Interval)	NNT
Control	426	134	31.46 (27.07-36.1)	
Intervention	494	109	22.06 (18.48-25.98)	11 (7-28)

Acute injury rates based on exposure were 3.83 injuries per 1000 player hours for the control group (95%CI; 3.21-4.54) and 2.77 injuries per 1000 player hours for the intervention group (95%CI; 2.27-3.34). Based on univariate analysis, unadjusted for cluster randomization, the relative risk of injury in the intervention group compared to the control group was 0.72 (95%CI; 0.54–0.94). Further details regarding exposure-based acute injury rates and relative risk are shown in Table 9.

Table 9: Exposure-based Acute Injury Rates and Relative Risk by Treatment Arm

Treatment Arm	Hours	Injuries	Injuries/1000 player hours (95% CI)	Relative Risk (95% CI)	Stat. Sig.*
Control	34955	134	3.83 (3.21-4.54)	1	
Intervention	39369	109	2.77 (2.27-3.34)	0.72 (0.56-0.94)	*p*=.01**

*Statistical significance

** Statistically significant based on p<0.05

4.2 Economic Evaluation

The primary target audience of this economic evaluation is the public payer. Analyses of all costs incurred and tracked during the time horizon of the study, including costs to the provincial health care insurance program and costs to the patient and/or extended health care provider are presented below. A presentation of accumulated costs specific to the publicly funded health care system follows as a secondary analysis for the provincial health care system perspective. Incremental costs for the primary outcome and cost-effectiveness values are summarized in Appendix K. Cost differences based on the mean cost of injury for both perspectives are presented in Appendix L. All costs are presented in Canadian dollars (CAD).

4.2.1 Public payer perspective

The total cost of the intervention program was $28,968.48. The mean cost was $58.64 per individual (*n* = 494) in the intervention group. Methods for determining the intervention costs are presented in Appendix G.

There were a total of 271 basketball injuries (141 control group, 130 intervention group) sustained by 225 players. Of the 141 injuries in the control group, there were 80 injuries (56.74%, 95%CI; 48.14-65.05) for which a player was reported to have received some form of medical intervention that, in consideration of study design, had a cost associated with that intervention. Of the 130 injuries in the intervention group, there were 70 injuries (53.85%, 95CI%: 44.89-62.62) for which a player was reported to have received some form of medical intervention having a cost associated with that intervention. As such, there was no difference between study groups in the proportion of players incurring medical costs (z=0.48, p=0.13). Four players with incomplete Injury Report Forms (IRFs) were considered to have no cost.

Distributional graphs and diagnostic quantile-norm plots were used to assess the cost outcomes for normality. Relevant costs incurred in the study population were not normally distributed. Rather, the distribution was extremely positively skewed with the presence of numerous outliers, as demonstrated in the stem and leaf plots in Figures 1 and 2.

Figure 1. Stem and leaf plot of total cost distribution in the control group.

0*** | 000,000,000,000,000,000,000,000,000,000,000,000,000,000,000, ... (396)

0*** | 203,211,220,227,231,236,249,283,283,294,309,324,325,366,370

0*** | 418,497,497,579,580

0*** | 612,632,641,697,742,768

1*** | 004

1*** | 252

4*** | 413

7*** | 928

Figure 2. Stem and leaf plot of total cost distribution in the intervention group.

0*** | 059,059,059,059,059,059,059,059,059,059,059,059,059,059,059, ... (448)

0*** | 213,218,224,249,251,256,264,267,279,343,364,365,368

0*** | 407,408,410,418,435,448,451,487,493,516,521,543,559,562,598

0*** | 606,631,638,658,769

0*** | 886

1*** | 072,090,111,141

1*** | 270

2*** | 851

7*** | 122

7*** | 791

8*** | 144,162

8*** | 377

9*** | 150

Subsequently, as the assumption of normality was not met, an attempt to transform the data was made. This was unsuccessful in normalizing the distribution of costs and therefore it was determined that non-parametric methods would be utilized. Specifically, the bootstrap *t*-test (unequal variances, 1000 repetitions), was used for comparative analyses of the independent variables and confidence intervals were calculated via non-parametric bootstrapping (1000 repetitions).

The primary outcome of this evaluation was selected a priori as the mean cost per player. With the extreme skewness of the cost data, the median and IQR values for all outcomes were not suitable to describe the central tendency of the distribution as they reflected either no cost or the cost of the intervention alone (Table 10).

Table 10: Non-Parametric Descriptors of Costs to Public Payer and Publicly Funded Health Care System

Treatment Arm	Median	IQ Range
Control Group	$0.00	0.00 - 0.00
Intervention Group	$58.64	58.64 – 58.64

4.2.1.1 All injuries

The mean cost per player, inclusive of the intervention costs, was $68.87 (95%CI; 26.67-111.06) per player for the control group and $202.23 (95%CI; 123.80-280.65) per player for the intervention group (t= -2.88, p=.001).

The mean cost of injury was $208.07 (95%CI; 80.86-335.27) for the control group and $545.62 (95%CI; 259.67-831.58) for the intervention group (t= -2.11, p=.01).

The total cost of preventing one basketball injury in a Calgary and area high school basketball player is $2000.40 (min=$1066.88, max=$17336.80).

4.2.1.2 Sensitivity Analyses

Gender

When considering injuries by gender, the mean cost per player inclusive of the intervention costs, for males was $29.96 (95%CI; 15.9-44.02) in the control group and $109.98 (95%CI; 46.56-173.39) in the intervention group (t= -2.33, p=.139). The mean cost per player inclusive of the intervention costs for females was $110.42 (95%CI; 25.05-195.79) in the control group and $292.26 (95%CI; 156.19-428.33) in the intervention group (t= -2.12, p=.023).

The mean cost of injury for males was $102.99 (95%CI; 61.71-144.26) for the control group and as $266.51 (95%CI; 0.00-601.35) for the intervention group (t= -.94, p=.31). The mean cost of injury for females was $295.40 (95%CI; 65.37-525.44) for the control group and as $703.68 (95%CI; 310.92-1096.43) for the intervention group (t= -1.72, p=.053).

The total cost of preventing one basketball injury in a Calgary and area high school male basketball player is $885.06 (min=$480.12, max=$3920.98). The total cost of preventing one basketball injury in a Calgary and area high school female basketball player is $4364.16 (min=$1454.72, max=implausible value).

Lower Extremity Injuries

When considering lower extremity injuries only, the mean cost per player inclusive of the intervention costs, was $62.94 (95%CI; 18.35-107.53) per player for the control group and $192.39 (95%CI; 110.02-274.75) per player for the intervention group (t= -2.80, p=.001).

The mean cost of lower extremity injury was $241.55 (95%CI; 84.98-398.11) for the control group and $623.30 (95%CI; 271.05-975.55) for the intervention group (t= -1.94, p=.024).

The total cost of preventing one lower extremity injury in a Calgary and area high school basketball player is $2847.90 (min=$1294.50, max=implausible value).

Ankle Sprain Injuries

When considering ankle sprains only, the mean cost per player inclusive of the intervention costs, was $22.55 (95%CI; 12.95-32.15) per player for the control group and $74.51 (95%CI; 66.16-82.85) per player for the intervention group (t= -7.82, p<.0005).

The mean cost of ankle sprain injury was $126.40 (95%CI; 79.36-173.44) for the control group and as $126.41 (95%CI; 69.05-183.76) for the intervention group (t= -.00012, p=1.0).

The total cost of preventing one ankle sprain injury in a Calgary and area high school basketball player is $987.24 (min=$571.56, max=$8313.60).

Acute Injuries

When considering acute onset injuries only, the mean cost per player inclusive of the intervention costs was $64.46 (95%CI; 21.26-107.66) per player for the control group and $191.25 (95%CI; 109.97-272.53) per player for the intervention group (*t*= -2.77, *p*=.001).

The mean cost of an acute injury was $204.93 (95%CI; 74.48-335.39) for the control group and as $601.01 (95%CI; 255.47-946.55) for the intervention group (*t*= -2.12, *p*=.005).

The total cost of preventing one acute injury in a Calgary and area high school basketball player is $1394.69 (min=$885.43, max$3541.72).

4.2.1.3 Analysis of Extremes

The high range values for physiotherapy, athletic therapy, chiropractic and massage therapy services as well as braces, surgery, emergency department visits and the intervention were substituted in the cost data spreadsheet and statistical analysis of this data was handled in the same manner as the public payer cost data. The mean cost per player, inclusive of the intervention costs, was $85.27 (95%CI; 32.46-138.08) per player for the control group and as $256.32 (95%CI; 163.44-349.20) per player for the intervention group (*t*= -3.15, *p*<.0005). The mean cost per player remains significantly greater in the intervention group for the worst case scenario.

The low range values for the same variables were substituted in the cost data spreadsheet and statistical analysis of this data was again handled in the same manner as the public payer cost data. The mean cost per player, inclusive of the intervention costs, was $57.41 (95%CI; 19.61-95.20) per player for the control group and as $151.56 (95%CI; 80.84, 222.28) per player for the intervention group (*t*= -2.38, *p*<.008). The mean cost per player remains significantly greater in the intervention group for the best case scenario.

The total cost of preventing one basketball injury in a Calgary and area high school basketball player ranges from $753.20 to $22236.50.

4.2.2 Publicly Funded Health Care System Perspective

A target funder of this injury prevention program is the publicly funded health care system, administered by Alberta Health & Wellness (AHW). Rationale for this secondary analysis is presented in section 3.2.1. The following costs are those payable solely by the publicly funded health care system in Alberta.

Of the 141 injuries in the control group, there were 56 injuries (39.72%, 95%CI; 31.58-48.29) for which a player was reported to have received some form of medical intervention that, in consideration of study design, may have had a cost to the publicly funded health care system associated with that intervention. Of the 130 injuries in the intervention group, there were 58 injuries (44.62%, 95%CI; 35.9-53.58) for which a player was reported to have received some form of medical intervention having a cost to the publicly funded health care system associated with that intervention. Again, costs incurred in the study population were not normally distributed, as demonstrated in the stem and leaf plots presented in Figures 3 and 4. Statistical analysis of the publicly funded health care system cost data was handled in the same manner as the public payer cost data (i.e. using non-parametric methods).

Figure 3. Stem and leaf plot of AHW cost distribution in the control group.

0** | 00,00,00,00,00,00,00,00,00,00,00,00,00,00,00,00,00,00,00,00, ... (406)

1** | 10,22,39,39,45,86,86

2** | 05,11,11,11,11,68

4** | 23,77,95

5** | 72,80

7** | 16

54** | 13

Figure 4. Stem and leaf plot of AHW cost distribution in the intervention group.

0** | 59,59,59,59,59,59,59,59,59,59,59,59,59,59,59,59,59,59,59,59, ... (451)

1** | 03,15,15,15,17,17,17,19,24,38,51,64,69,78

2** | 01,24,28,36,49,63,70,70,93,99

3** | 65,76

4** | 10,18,23,31

5** | 00,06,06,21

7** | 86

8** | 88

9** | 96

53** | 67

56** | 44,64

4.2.2.1 All Injuries

When considering all injuries, the mean cost per player, inclusive of the intervention costs, was $29.46 (95%CI; 3.63-55.29) per player for the control group and $147.27 (95%CI; 92.63-201.91) per player for the intervention group (t= -3.77, p<.0005).

The mean cost of injury was $89.02 (95%CI; 15.37-162.67) for the control group and $336.80 (95%CI; 134.19-539.41) for the intervention group (t= -2.23, p=.004).

The cost to the publicly funded health care system to prevent one basketball injury in a Calgary and area high school basketball player is $1767.15 (min=$942.48, max=$15315.30).

4.2.2.2 Sensitivity Analyses

Gender

When considering injuries by gender, the mean cost per player for males including the mean cost of the intervention program was $11.53 (95%CI; 4.88-18.18) in the control group and $89.17 (95%CI; 44.50-133.84) in the intervention group (t= -3.33, p=.534). The mean cost per player including the mean cost of the intervention program for females was $48.62 (95%CI; 0.00-98.90) in the control group and $203.98 (95%CI; 99.53-308.43) in the intervention group (t= -2.69, p=.002).

The mean cost of injury for males was $39.63 (95%CI; 18.47-60.79) for the control group and $158.50 (95%CI; 0.00-385.37) for the intervention group (t= -.99, p=.262). The mean cost of injury for females was $130.07 (95%CI; 0.00-265.54) for the control group and $437.77 (95%CI; 161.51-714.03) for the intervention group (t= -1.88, p=.023).

The cost to the publicly funded health care system to prevent one basketball injury in a Calgary and area high school male basketball player is

$854.04 (min=$465.84, max=$3804.36). The cost to the publicly funded health care system to prevent one basketball injury in a Calgary and area high school female basketball player is $3728.64 (min=$1242.88, max=implausible value).

Lower Extremity Injuries

When considering lower extremity injuries only, the mean cost per player was $25.19 (95%CI; 0.57-49.82) per player for the control group and $141.92 (95%CI; 86.39-197.44) per player for the intervention group (t= -3.75, p<.0005).

The mean cost of lower extremity injury was $96.68 (95%CI; 0.42-192.94) for the control group and $388.09 (95%CI; 150-54-625.65) for the intervention group (t= -2.14, p=.007).

The cost to the publicly funded health care system to prevent one lower extremity injury in a Calgary and area high school basketball player is $2568.06 (min=$1167.30, max=implausible value).

Ankle Sprain Injuries

When considering ankle sprains only, the mean cost per player was $6.37 (95%CI; 2.88-9.85) per player for the control group and $65.66 (95%CI; 60.96-70.37) per player for the intervention group (t= -20.22, p<.0005).

The mean cost of ankle sprain injury was $35.69 (95%CI; 18.54-52.83) for the control group and $55.96 (95%CI; 22.65-89.27) for the intervention group (t= -1.02, p=.266).

The cost to the publicly funded health care system to prevent one ankle sprain in a Calgary and area high school basketball player is $1126.51 (min=$652.19, max=$9486.40).

Acute Injuries

When considering acute injuries only, the mean cost per player was $26.88 (95%CI; 1.78-51.98) per player for the control group and $143.04 (95%CI; 87.24-198.85) per player for the intervention group (t= -3.74, p<.0005).

The mean cost of an acute injury was $85.45 (95%CI; 8.53-162.38) for the control group and $382.53 (95%CI; 130.30-634.76) for the intervention group (t= -2.29, p=.001).

The cost to the publicly funded health care system for preventing one acute injury in a Calgary and area high school basketball player is $1277.76 (min=$813.12, max=$3252.48).

4.2.2.3 Analysis of Extremes

The high range values for surgery, emergency department visits and the intervention were substituted in the cost data spreadsheet and statistical analysis of this data was handled in the same manner as the public payer data. The mean cost per player, inclusive of the intervention costs, was $35.25 (95%CI; 3.74-66.76) per player for the control group and $190.99 (95%CI; 124.31-257.69) per player for the intervention group (t= -4.25, p<.0005). The mean cost per player remains significantly greater in the intervention group for the worst case scenario.

The low range values for the same variables were substituted in the cost data spreadsheet and statistical analysis of this data was handled in the same manner. The mean cost per player, inclusive of the intervention costs, was \$26.24 (95%CI; 3.82-48.65) per player for the control group and \$105.55 (95%CI; 59.24-151.86) per player for the intervention group (t= -2.98, p<.0005). The mean cost per player remains significantly greater in the intervention group for the best case scenario.

The cost to the publicly funded health care system to prevent one basketball injury in a Calgary and area high school basketball player ranges from \$634.48 to \$20246.20.

4.2.3 Resource Use

The most common treatment for all injuries was ice. Ice application was reported as a medical intervention received as a direct result of a basketball injury on 103 of 271 IRFs (38.0%, 95CI%: 32.20-44.08). Ice was considered as a no-cost intervention in this evaluation. A disaggregated presentation of all direct health cost items that were costed and tracked in this evaluation are included in Tables 11 and 12.

Table 11: Disaggregated Costs to AHCIP by RCT Treatment Arm

	Control Group			Intervention Group		
Type of resource	amount	unit cost	total cost	amount	unit cost	total cost
General Practitioner (I)	31	$28.97	$898.07	39	$28.97	$1,129.83
General Practitioner (F)	4	$28.97	$115.88	13	$28.97	$376.61
ER Physician (I)	13	$35.67	$463.71	14	$35.67	$499.38
Sport Med Physician (I)	4	$62.87	$251.48	2	$62.87	$125.74
Sport Med Physician (I)*	4	$55.16	$220.64	11	$55.16	$606.76
Sport Med Physician (F)	10	$28.97	$289.70	28	$28.97	$811.16
Orthopaedic Surgeon (I)	2	$81.57	$163.14	9	$81.57	$734.13
Orthopaedic Surgeon (F)	4	$24.29	$97.16	20	$24.29	$485.80
Chiropractor (I)	11	$13.23	$145.53	4	$13.23	$52.92
Chiropractor (F)	18	$13.23	$238.14	20	$13.23	$264.60
surgery	1	$4,947.91	$4,947.91	6	$4,947.91	$29,687.46
xrays	28	variable	$844.23	35	variable	$1,080.14
MRI	1	$474.00	$474.00	7	$474.00	$3,318.00
CT scan	0	$296.00	$0.00	1	$296.00	$296.00
bone scan	3	$334.56	$1,003.68	4	$334.56	$1,338.24
other	15	variable	$2,398.46	21	variable	$2,977.54
Total (AHCIP)	149	xx	$12,551.73	234	xx	$43,784.31

*study physician
(I=initial visit, F=follow-up visit)

Table 12: Disaggregated Costs to Patient and/or Extended Health Care by RCT Treatment Arm

	Control Group			Intervention Group		
Type of resource	amount	unit cost	total cost	amount	unit cost	total cost
Chiropractor (I)	11	$46.77	$514.47	4	$46.77	$187.08
Chiropractor (F)	18	$21.77	$391.86	20	$21.77	$435.40
Physiotherapist (I)	31	$88.00	$2,728.00	35	$88.00	$3,080.00
Physiotherapist (F)	194	$44.00	$8,536.00	260	$44.00	$11,440.00
Athletic Therapist (I)	0	$57.50	$0.00	1	$57.50	$57.50
Athletic Therapist (F)	0	$47.50	$0.00	3	$47.50	$142.50
Massage Therapist	4	$57.45	$229.80	4	$57.45	$229.80
Other health practitioners	1	$15.00	$15.00	20	variable	$550.00
cast	2	$20.00	$40.00	2	$20.00	$40.00
crutches	14	$26.00	$364.00	20	$26.00	$520.00
brace	29	variable	$3,944.38	31	variable	$9,921.42
other	5	variable	$21.85	10	variable	$543.11
Total (patient-payable/EHC)	309	xx	$16,785.36	410	xx	$27,146.81

(I=initial visit, F=follow-up visit)

The most substantial individual and aggregate cost for the public payer in both treatment arms was surgery as a result of ACL injury. ACL surgical repair was costed at $4791.91. Major additional costs associated with the ACL injuries included physiotherapy visits (mean $1100.00), bracing (mean $1161.04), and diagnostic imaging (mean $403.99). 55.52% (95%CI; 55.21-55.83) of the total costs and 69.76% (95%CI; 69.38-70.14) of the publicly funded health care costs incurred during the study were attributable to the seven individuals with ACL injury.

Physiotherapists were the health care professionals that accumulated the most resource use in both volume and cost. There were 31 injuries in the control group that resulted in at least one physiotherapy visit (21.99%, 95%CI; 15.45-29.73) and 35 injuries in the intervention group that resulted in at least one physiotherapy visit (26.92%, 95CI%: 19.52-35.41). Once again, the ACL-injured players were the greatest source of this cost burden. In the control group, 23 of the 194 reported physiotherapy visits (11.86%, 95%CI; 7.67-17.26) were due to the one ACL injury in the group. In the intervention group, 123 of the 260 reported physiotherapy visits (47.31%, 95%CI; 41.11-53.57) were due to the six ACL injuries. When ACL injuries were excluded from analyses for exploratory purposes, the difference of the mean cost per player between the study groups was still significant.

Although costs for medication and taping were not assessed in this evaluation, for the reasons stated in Appendix F, the resource use of these two interventions is included for descriptive purposes. Medication use was reported in 26 of 141 injuries (18.44%, 95%CI; 12.41-25.84) for the control group and in 15 of 130 injuries (11.54%, 95%CI; 6.6-18.32) for the intervention group ($z=1.58$, $p=.113$). Taping was reported in 47 of 141 injuries (33.33%, 95%CI; 25.63-41.76) for the control group and in 33 of 130 injuries (25.39%, 95%CI; 18.16-33.76) for the intervention group ($z=1.43$, $p=.152$).

Chapter Five: DISCUSSION

The purpose of this study was to identify the resources and costs associated with a sport injury prevention program in Calgary and area high school basketball players and to calculate the cost of such a program in preventing injury. There are no published prospective economic evaluations of an injury prevention strategy in this population and few publications of the same in other sports, age groups or levels of competition. The intent in completing this economic evaluation was to provide health care policy makers and funding providers with information regarding an often overlooked health issue in Canada – injury. This information could potentially influence future health care resource use, costs and accessibility issues due to the burden of injury on our health care system.

5.1 Summary of Results

5.1.1 Randomized Controlled Trial

5.1.1.1 Injury Outcomes

The injury rates in the control group in this RCT were consistent with basketball injury rates in previously published literature (Arendt, and Dick, 1995; Gomez, DeLee, and Farney, 1996; McKay, Goldie, Payne, and Oakes, 2001; Messina, Farney, and DeLee, 1999). Minor discrepancies between studies could be, in part, attributed to the differences in injury definitions. A more restrictive definition would likely result in lower injury rates whereas broader injury definitions would likely result in higher injury rates. The populations under investigation (national level, college, and high school basketball players) may also impact the comparative injury rates.

5.1.1.2 Effectiveness

In this RCT, the protective effect of a balance board training program in preventing all (i.e. inclusive of acute and gradual onset, upper and lower quadrants to males and females) injuries in high school basketball players was not statistically significant. However, there was a trend toward a protective effect that could be considered clinically relevant. Balance training alone or in conjunction with other pre-season training strategy components has been shown to reduce the incidence of injury in sports such as basketball, European handball, volleyball and soccer (McGuine, and Keene, 2006; Myklebust et al., 2003; Olsen et al., 2005; Tropp et al., 1985; Verhagen et al., 2004; Wedderkopp et al., 2003; Wedderkopp et al., 1999) and in high school physical education students (Emery et al., 2005). The protective trend in this RCT, with consideration of related research with statistically significant findings, arguably still gives impetus to investigate the economic impact and cost-effectiveness of this particular program.

Although the primary outcome of the RCT was the difference in injury rates between treatment arms for all injuries, subgroups (gender) and injury types (lower extremity, ankle sprain and acute injury) were also identified for analysis. Injury rates between males and females were different but the protective effect of the program between these groups was not. The balance training program also did not demonstrate a protective effect for lower extremity or ankle sprain injuries, however; again there was arguably a clinically relevant trend. Additionally, there were more ACL injuries reported in intervention group (*n*=6) than in the control group (*n*=1), however with so few ACL injuries the relevance of this finding beyond chance is unclear. This training program was effective in reducing the risk of acute onset injuries in high school basketball players (RR = 0.72 [95% CI; 0.56–0.94]).

The RCT analysis utilized a Poisson regression model, with adjustment for clustering by team, to calculate injury rates and 95% confidence intervals. Multivariate Poisson regression analysis was done to estimate the relative risk of injury in the training group compared to the control group (Emery, Rose, McAllister, and Meeuwisse, in press). It should be noted that these cluster-adjusted outcomes did not change the interpretation of the effectiveness of the training program.

5.1.1.3 Number needed to treat (NNT)

The impetus for NNT has grown out of the need for an easily interpretable summary of the difference in treatment effects (Alemayehu, and Whalen, 2006, p. 181). The best case scenario for NNT to avoid one injury would be '1', when every patient with treatment benefited, but no patient given control benefited. NNT point estimates in this RCT ranged from 11 to 24, the 95% confidence limits ranged from 6 to 'implausible values'. These implausible values were considered so because they were negative values, indicating individuals would have to not be treated with the intervention '*x*' times to avoid an injury (i.e. suggesting the intervention was harmful). This is not surprising, where the protective effect of the program was not statistically significant. In the two cases (females and lower extremity injury) where a negative NNT occurred from the upper confidence limit of the ARR, no upper confidence limit for the NNT was reported as this outcome is not considered useful (McQuay & Moore, 1997).

5.1.2 Economic Evaluation

In this study, 135 individuals with 150 injuries sustained a cost burden in the study, with 114 of these injuries resulting in a cost to the publicly funded health care system. The intervention group incurred significantly more costs per player than the control group in all analyses based on mean cost per player (including cost of intervention in the intervention group), with the exception of males where the difference between treatment arms was not significant for total costs (p=.139), nor costs to the public health care system (p=.534).

5.1.2.1 Resource Use

Although the total number of injuries sustained in the intervention group was less than in the control group, the overall health care burden was greater in the intervention group in both absolute and relative values. As shown in Tables 11 and 12, in the majority of cases the resource use specific to each type of practitioner and/or equipment was greater in the intervention group than the control group, with the exception of initial visits to a sport medicine physician and initial visits to a chiropractor where the costs were greater in the control group. Additionally, the total number of visits was equal in both groups for cast supplies and massage therapy, although a greater proportion of injured players in the intervention group received these services.

Overall, ice was the most commonly reported intervention. The most commonly used resources that were assessed a cost in this evaluation were physiotherapy services, family physicians, x-rays and bracing. Surgery occurred as a result of only 2.58% of the injuries but was the most costly intervention. When subgroups and injury types were stratified for analyses females had the highest overall resource use.

5.1.2.2 Injury Costs

The aggregate cost of injuries during the time horizon of this study, inclusive of costs to the public health care system and patients / extended health care providers but excluding the intervention costs, was $100,268.21. The aggregate cost of injuries to the public health care system during this study, excluding the intervention costs, was $56,336.04. Aggregate costs by treatment arm are not the most useful outcome measures because the number of individuals in each treatment arm is not equal. The aggregate values that are presented do however provide a quantification of overall health care impact from a season of basketball injuries in selected Calgary and area high schools.

Based on all injury, the mean cost per player in the intervention group ($202.23) was greater than that in the control group ($68.87) ($p$=.001). In addition, the mean cost of injury, for those who sustained injury, in the intervention group ($405.41) was greater than that in the control group ($107.28) ($p$=.01).

The stratified analyses by gender and sensitivity analyses by lower extremity injury, ankle sprain injury and acute injury were included to parallel the RCT investigation. Males in either treatment arm were less likely to sustain an injury than females and the cost analyses reflect lower costs for males as compared to females in all economic outcomes as well. Although the lower extremity and ankle sprain injury rates between treatment arms were not significantly different, the cost analyses reflect significantly higher costs in the intervention group for both injury types (p=.001 and p<.0001 respectively). The acute injury rate was significantly lower in the intervention group but the related mean costs per player and mean cost per injury were significantly higher in the intervention group (p=.001 and p=0.005 respectively).

There was no difference in the mean cost of injury (total costs and publicly funded health care costs) between the control and intervention groups for males (p=.31 and .262), ankle sprain injuries (p=1.0 and .266) or for female total costs (p=.053). The mean costs of injury were calculated without the cost of the intervention and the results suggest that the differences in mean cost per player in these subgroups and injury types could be attributed to the cost of the intervention.

The impact of the ACL injuries on the cost outcome of this economic evaluation cannot be ignored. As reported in the section 4.2.3, the majority of costs (55%) incurred in this study were related to seven ACL injuries. In the intervention group, 77.39% of the publicly funded health care costs were due to the six ACL injuries in that group. Although the occurrence of ACL injury was greater in the intervention group, at this time it would be remiss to assume that a wobble board program increases the risk of ACL injury. The number of ACL injuries in the study population is too small to make any inferences regarding risk. Although the resource use and subsequent cost of these ACL injuries were great, it is important to note that when these outlier costs were removed from the data for exploratory purposes, the difference of the mean cost per player between the control and intervention groups was still significant.

In the case of mean cost per injury, when the ACL injuries are removed from the analysis, the difference in mean cost of injury between the control and intervention group is no longer significant, for all injury and both subgroups and all injury types. This was expected, as the cost of the intervention is not included in this outcome and the extreme outliers have been removed.

Although the resource use and injury cost data provide some insight into the impact of a season of Calgary and area high school basketball injuries, this information is of little utility in health care funding decisions. Cost of injury data is not helpful for decision makers in the context of setting priorities for resource allocation and research (Currie et al., 2000, p. 175). Consequently, measures of cost for effect (i.e. injury prevention) were also calculated in this evaluation and are discussed below.

5.1.2.3 Cost per injury prevented

The cost to the public payer to prevent one injury is $2000.40. The cost to the publicly funded health care system to prevent one injury is $1767.15. These costs were calculated by multiplying the relevant NNT by the difference in mean costs between the treatment arms. The use of NNT in determining cost-effective ratios is not standard practice. The recommended method from the Canadian Agency for Drug and Health Technology Assessment (2006) is the incremental cost-effectiveness ratio (ICER). An ICER is traditionally calculated by dividing the additional costs between the comparators by the additional benefits between the comparators (Palmer, and Raftery, 1999; Sendi, Gafni, and Birch, 2002). In prevention research, the outcome is really the absence of the event, in this case injury and makes the denominator of the ICER difficult to express. It is important to note that the substitution of NNT to express cost-effectiveness is still equivalent to taking the ratio of the incremental costs over the incremental effect (expressed as the reduction of rate of injury in the treatment group compared to control), although a slight cost difference exists due to the necessity of rounding for NNT integer values. Arguably the substitution of NNT in a cost-effectiveness measure provides a clinically relevant view of the effectiveness and is generally easily interpreted (Alemayehu, and Whalen, 2006). Subsequently, although the cost per injury prevented outcomes presented in this evaluation do represent a cost-for-effect value, the term incremental cost-effectiveness ratio will not be formally applied in this discussion.

5.2 Limitations

5.2.1 RCT Limitations

The following limitations specific to the RCT are also relevant to the economic evaluation, as either limitation may have contributed to a non-significant finding regarding program effectiveness.

5.2.1.1 Compliance

Self-reported compliance to the home-based portion of the training program was poor (298/494 or 60.3%). The median number of sessions completed was nine (range 0 – 42).

5.2.1.2 Program Timing

The balance training program was implemented at the beginning of season play as the turnover period from fall sports to winter sports (i.e. basketball) was immediate in the Calgary high school system. Although there is no specific evidence to support the impact of the timing of the program in this RCT on the injury outcomes, a balance training program in high school basketball players in Wisconsin (McGuine, and Keene, 2006) that demonstrated stronger evidence of a protective effect was a pre-season program with a maintenance phase once the season began. If it had been feasible, it would have been logical to try to implement the program before the start of the season, wherein the full effect of the program could have been realized for the entire basketball season.

5.2.2 Economic Evaluation Limitations

5.2.2.1 Accuracy of Cost Valuation

The quality of an economic evaluation is greatly dependent on the quality of the data collected. Every attempt to obtain accurate costs or cost estimates was undertaken to minimize this limitation. Limitations regarding the specificity of the cost data collected challenge the potential accuracy and subsequent usability of this economic evaluation. In most cases, pricing determinants were estimated, albeit with the intent of utmost accuracy. This evaluation sought cost information at the level of each individual player wherever possible. Although patient-specific costing and micro-costing are considered as the more precise methods for cost valuation (Baladi, 1996), there are still potential limitations in the accuracy of the resource use data and the costs incurred to all parties.

However, even with access to actual provincial health care files cost valuation can still be an exercise in estimation, particularly where there are ambulatory care services. From this economic evaluation it appears that an injury report form tracking medical and paramedical treatments, with health care provider and administrative staff consultations for clarification, can provide a reasonable representation of direct health care costs incurred (with rationale for all assumptions) as a direct result of high school basketball injury.

Cost valuation at the level of the individual player or patient, particularly without access to individual health care insurance files, was a time consuming process. A cost diary, with design to allow for more specific information on practitioners, visits, patient incurred costs may ease the time resources (and payroll, if applicable) necessary to perform an economic evaluation, as well as improve the accuracy of costs collected. The feasibility of compliance to completion of such a diary with the adolescent population may be questionable, given the moderate adherence to completing the training compliance journal (73%).

Ambulatory care costing

Ambulatory care is sometimes referred to as outpatient care and encompasses the treatment and services provided to individuals who attend a hospital or patient care centre and are not formally admitted to the facility. To date, ambulatory care services are costed on a very limited basis in the Canadian provinces (Canadian Institute for Health Information, 2005). This is an evolving area of health economics in Alberta and in Canada.

Currently, in the Calgary Health Region, emergency room visits are only costed at the Alberta Children's Hospital (ACH) and day surgeries are only costed at the Rockyview General Hospital (RGH). This situation presents a possible limitation to this economic evaluation as the data sources were not necessarily the sites for actual care and subsequent accumulation of health care costs. However, the costing of emergency room visits from ACH data was seen as suitable for this evaluation, as the study population was eligible to and arguably likely to attend this facility. The ACL surgeries of the study population were not necessarily completed at RGH and there was no data to assess whether costs between surgical centres were similar, although this was believed to be the case (M. Brandt, personal communication, January 16, 2006).

In the case where an ambulatory care service could not be directly costed (i.e. casting/splinting), professional fees and laboratory costs resulting from these visits were captured from a variety of sources, as described in Appendix F. This cost valuation is a limitation of the study, in its piecemeal costing approach. Although this cost valuation was a source of uncertainty in the evaluation, there were no reasonable sources identified on which to even substitute values for a sensitivity analyses. However, there were only six individuals who reported any casting or splinting and the impact of these costs on the overall evaluation are seen as minimal.

5.2.2.2 Uncertainty

The uncertainty amongst the cost valuation of paramedical service charges, as well as supplies and equipment prices challenged the analyses and present a limitation in this economic evaluation. Beyond the efforts to have solid rationale for all costings as noted above, several strategies were employed to deal with this limitation. These strategies were in the form of presenting confidence limits for the cost data where feasible and in the sensitivity analyses, most specifically the in analysis of extremes. Briggs, and Sculpher (1995) discuss uncertainty in economic evaluation data and indicate that if the resource use data were collected within a RCT, the uncertainty can be reflected by confidence interval using statistical techniques. While confidence intervals were presented for all cost outcomes, a decision was made to take the sensitivity analysis one step further. As such, the uncertainty of the cost valuations was also handled in an analysis of extremes for the mean cost per player and cost per injury prevented outcomes. As there were multiple sources of uncertainty, the analysis of extreme approach was selected to present the best and worst case scenarios. There are numerous other methods for dealing with uncertainty, including one-way sensitivity analysis where one parameter is changed at a time, multi-way sensitivity analysis where two or more parameters are changed simultaneously, and Monte Carlo simulation where prior probability distributions are assigned to each input parameter (Lord, and Asante, 1999). Briggs, and Sculpher (1995) state that "unless there is good reason to assume independence, extreme scenario analysis should be employed to examine the effects of a best/worse case scenario if the maximum robustness of results is to be demonstrated" (p. 362). Lord, and Asante (1999) state that "these extreme scenarios are very unlikely to occur in reality but can be very informative. If one intervention remains superior under the most extreme scenario, then this is strong evidence for its adoption." (p. 325). The analysis of extreme for both perspectives maintained the outcome that the mean costs per player were significantly higher in the intervention group than in the control group but also resulted in some very wide range values for the cost to prevent one injury outcomes.

5.2.2.3 Cost Allocation

Physiotherapy

As stated in Appendix F, physiotherapy was considered as a cost that was not borne by the publicly funded health care system. The rationale for choosing to include physiotherapy as a patient or extended health care cost includes two main factors. The first consideration was expert consultation, in the form of contact with physiotherapists who work in private practice. The consensus was that the majority of sport related injuries did not receive community funding, with the possible exception of post-surgical and post-fracture patients. The second consideration was that not all physiotherapy clinics in the Calgary Health Region have opted to participate in the Community Rehabilitation Program and therefore, not all clinics nor patients would have opportunity to access the funding, even if their injuries made them eligible. This assumption could be considered a limitation of the evaluation, but the rationale for the assumption should be argued as a valid one.

5.2.2.4 Excluded costs

The study design did not well account for the details necessary to accumulate or estimate all potential costs. Specifically, the design of the IRF did not allow for sufficient data regarding resource use of taping and medications to be collected and therefore these items could not be assessed in the economic evaluation. Additionally, productivity loss due to time away from sport, school and/work was not tracked. This represents potential costs that were not assessed and is a limitation of this evaluation.

Taping & Medication

The impact of not including taping and medication costs in this economic evaluation on the outcomes can only be speculated upon. No specific data was collected on the quantity, duration, or type of product that was used in either case although CHR costings for surgeries and emergency department visits do account for medication dispensed. The difference in resource use between groups for both taping and medication was not significant (p=.152 and .113 respectively). Although the cost impact of the injuries may increase slightly in both groups with the inclusion of these costs, the marginal costs between the groups would likely be minimally impacted. The exclusion of these costs from the provincial health care system perspective would have no effect as these costs would not be borne by the publicly funded health care system, with the exception of those costs that were captured in the CHR costings.

Indirect Costs

In health economics, indirect cost usually refers to the productivity costs that may be the consequence of the use of a particular technology (Culyer, 2005, p. 174). These costs were not included in this evaluation as they were not appropriately considered in the original study design. The public payer was selected as the primary perspective for this evaluation because the study design and data collection did not allow for information regarding indirect costs and this eliminated the societal perspective as an element of the evaluation, the preferred perspective of CADTH. The publicly funded health care system was selected as a secondary perspective, with costs borne by the patient and/or extended health care provider excluded as Alberta Health and Wellness (AHW) was considered a target audience. The adoption and funding of the program, if recommended, was targeted at AHW. Although the CADTH guidelines (2006) indicate that the publicly funded health care system perspective also includes indirect costs, the indirect costs of adolescent time loss from sport is not well developed and may be of limited impact.

5.2.2.5 Bias

The study therapists assigned to each school were advised that they were not to provide any specific recommendations regarding treatment to the players, in that they were not to refer to a specific practitioner. This was requested so as to minimize undue bias to certain forms of health care and therefore potentially influence the quantity and type of health care service or product sought and received. However, no data was specifically collected on this occurrence and is a potential limitation of the study.

The payroll costs of the study therapists were excluded from the analyses but the potential for an underestimation of paramedical costs still exists as players may not have sought other medical or paramedical consultation since they were being assessed at school by a qualified therapist. The potential for overestimation of paramedical costs is also possible as the assessment by a qualified therapist may have initiated further follow-up, even without referral or suggestion by the therapist. Additionally, players were able to access the study physician (a sport medicine physician) without physician referral. We cannot assume what percentage of people would have moved on to a sport medicine physician after initially seeing a general practitioner, and this is also a limitation of the study. It is important to note that this unmeasured factor would not be expected to differ between study groups, based on the random allocation of the study groups.

5.2.2.6 Statistics

The data in this evaluation, both of the RCT itself and of the economic aspect remains unadjusted for clustering.

Distribution of costs

It is a common issue in economic evaluations that the burden of illness or injury is not normally distributed, with some individuals incurring no costs, many incurring a few costs and a small proportion of individuals incurring very large costs (Briggs, Nixon, Dixon, and Thompson, 2005; Rutten-van Molken, van Doorslaer, and van Vliet, 1994). O'Hagan, and Stevens (2001) report that "the distribution of cost data is typically markedly skewed, and may well be multimodal" (p. 304).

There is no consensus as to the most appropriate method for dealing with the skewed nature of cost data. Most parametric methods require that the sample has been taken from a normal distribution with equal variances. Rutten-van Molken et al. (1994) present several reasons for the challenging, sometimes impossible, task of statistical analysis of economic data: Often, sample size is too small and the economic evaluation lacks statistical power to test differences in costs, even when the power is sufficient to detect differences in effectiveness in the RCT. The sample size needed to conduct economic evaluations in a clinical trial is always likely to be larger than the sample size needed for the clinical evaluation itself and suggest that "second best analyses" will remain necessary (Rutten-van Molken et al., 1994).

The statistical analysis of data that is not normally distributed is still possible. The strategies of data transformation or non-parametric methods are most commonly applied in economic evaluations (Lord, and Asante, 1999; Rutten-van Molken et al., 1994; Verhagen et al, 2005), although Bayesian methods have also been utilized (O'Hagan, and Stevens, 2001, 2003). Logarithmic transformation of this study data was not successful in normalizing the distribution, even when individuals without injury were excluded. This eliminated logarithmic transformation as a strategy for dealing with this dataset. Consequently, non-parametric bootstrapping was used to estimate confidence intervals. A bootstrapping *t*-test was used to compare differences between the independent variables. Bootstrapping is a resampling technique, using replacement from the original sample in order to generate an empirical estimate of the entire sampling distribution of a statistic and is an alternative to inference based on parametric assumptions (Mooney, and Duval, 1993). The output of bootstrapping will vary slightly each time the technique is run on the same data because the random resampling is unlikely to be replicated.

In addition to challenges with data distribution patterns, the ability to estimate confidence intervals for the cost per injury prevented values posed another statistical challenge. Ultimately, the confidence limits of the NNT were inputted against the respective point estimates of the mean cost per player to present the estimates of a minimum and maximum cost per player. This is certainly a limitation of the evaluation, although these NNT confidence limit values were then with the point estimates in the analysis of extremes to present best and worst case scenarios for the cost per injury prevented values.

5.3 Other Economic Studies

There is little published research on economic evaluation of sport injury prevention strategies, which leaves limited opportunity to compare the outcomes of this evaluation with other literature. The study of Verhagen et al. (2005) is the only similar study in terms of methods, measures or outcomes; although ankle injury alone, in adult Dutch volleyball players was the focus of their economic evaluation. Their findings are perhaps comparable with the findings of this economic evaluation that were specific to ankle sprains. The cost to prevent one ankle sprain in the study of Verhagen et al. (2005) was €444.03 ($626.35 CAD January 9, 2006 Bank of Canada nominal rate). Of note, their evaluation was inclusive of indirect costs, as well as estimates for medication and taping supplies. The cost of preventing one ankle sprain in our study was $987.24 for all costs and $1126.51 for publicly funded health care costs. The intervention program of Verhagen et al. (2005) was not a home program and therefore balance boards were not supplied to each player. Instead five boards were distributed to each team in the intervention group, resulting in a much lower mean intervention cost than in our study. Injury costs were tracked for the period that an athlete was unable to participate due to the injury, rather than considering potential costs for bracing, rehabilitation and follow-up physician visits that may have occurred upon returning to sport.

The cost of a balance board training program in preventing an ankle sprain in Calgary and area high school basketball players was over three hundred dollars more than the cost of preventing an ankle sprain in adult Dutch volleyball players. Discrepancies in the population under evaluation, data collection and cost valuation methods and health care usage patterns are all possible explanations for the cost difference and these discrepancies make the designation of one program as more cost-effective than the other an illogical decision.

5.4 Generalizability

Regardless of the specific results, the generalizability of the economic evaluation in its present design can be discussed. Health care costs are based on Alberta rates, and where possible, Calgary Health region costings.

Additionally, the study population is specific to adolescent basketball players in Calgary and area. Both of these factors limit the generalizability of the findings. However, the strength of a quality economic evaluation lies in part in its transparency and reproducibility for variable values. Cost valuation methods and assumptions are stated explicitly. Variant resources and costs can be entered in the model to obtain relevant results across the country or internationally.

5.5 Health Services Impact

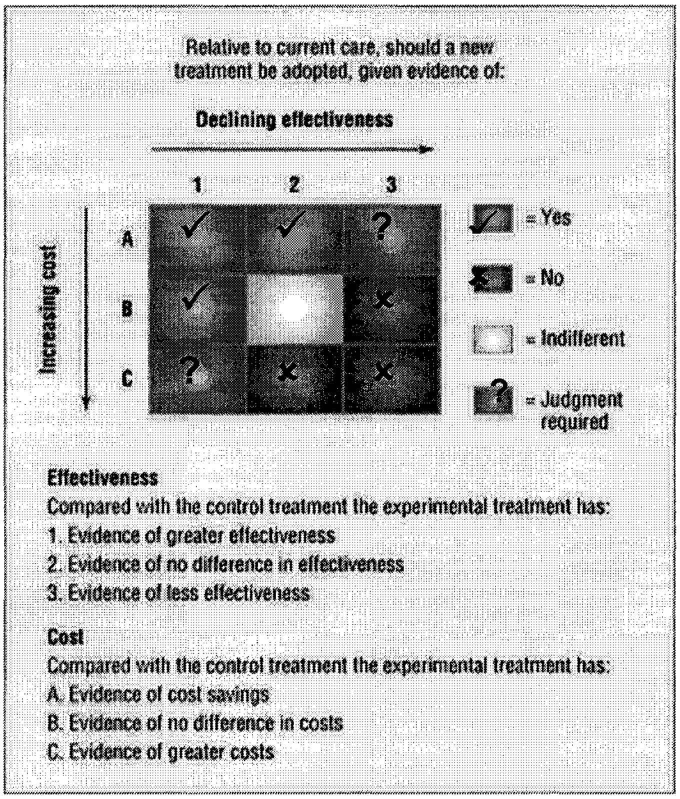
The impact of the injuries suffered in Calgary and area during the 2004/2005 high school basketball season on the $10.3 billion annual Alberta health care budget (Government of Alberta, 2006) likely seems negligible and perhaps in comparison to the health care impact of high profile illnesses such as cancer and heart disease, is so. However, consider that this was one small population representing many more basketball players (and potentially athletes of other sports) and therefore more injuries and more costs. Consider also the long-term outcomes of injuries, particularly from the development of osteoarthritis and the potential economic impact swells. The investigation of resource use and the subsequent health care impact to AHW, CHR, injured players, their parents and potential extended health care insurance providers as a result of high school basketball injuries is not only relevant to these parties, but also to health care practitioners and local school boards.

With the two perspectives of this evaluation in mind, consideration of whether to provide funding for this balance training program in high school basketball programs arises. Economics is about choice, given the scarcity of resources (Guyatt et al., 1986, p.401). The notion of scarcity used by economists means that societies do not have enough resources to meet all claims or needs (Donaldson, and Shackley, 1997). The major consideration to any of the target audiences is therefore that of opportunity cost. Opportunity cost is defined as the benefits achievable in some other programme which has been forgone by committing the resources in question to the first programme (Drummond, Stoddart, and Torrance, 1987, p. 7). If the balance training program of this RCT was not selected, the opportunity costs could be considered the injuries that would not be prevented by choosing the 'do-nothing' option. If the balance training program was selected for funding, the opportunity costs of funding this program have to be considered the actual monetary value of the resources that would be used because the specific benefits of another health care program that would be forgone are outside of the scope of this evaluation.

In today's environment of resource scarcity, the use of resources in one manner prevents their use in other ways (Palmer, and Raftery, 1999). Ultimately, economic evaluations are useful in addressing two levels of question, questions of technical efficiency and questions of allocative efficiency (Donaldson, and Shackley, 1997). Technical efficiency is concerned with how to best deliver a program - the same group will be treated but by what method to achieve a given objective. A more technically efficient program would be less costly and at least as effective as the status quo (Donaldson, Currie, and Mitton, 2002). In terms of allocative efficiency, all health care programs have to compete with each other for implementation. The question as to where health care funding should be allocated for maximum efficiency cannot be answered in this evaluation. The cost per injury prevented outcome in this RCT is related to the status quo option of the same RCT - the natural unit denominators ("per injury prevented") of a cost-for-effect outcome are difficult to compare against other natural unit denominators (such as 'life year gained', 'tumours correctly diagnosed', etc) as it is difficult to compare the value of one injury prevented to one tumour diagnosed, for example.

Because the outcome of this evaluation leads the decision maker away from technical efficiency, as the intervention was questionably more effective but certainly more costly, another strategy to aid decision makers was sought. Donaldson et al. (2002) proposed a matrix where comparison of new treatments with current care could be undertaken (see Figure 5).

Figure 5. Effectiveness-cost matrix for comparison of new treatment with current care.



From "Cost effective analysis in health care: contraindications," by C. Donaldson, G. Currie, and C. Mitton, 2002, *British Medical Journal, 325*, p.892. Copyright 2002 by C. Donaldson, G. Currie, and C. Mitton. Adapted and reprinted with permission.

The intervention under evaluation can be placed in a cell based on its effectiveness and its cost and funding considerations can potentially be clarified based on that positioning. In this matrix, interventions without greater cost and with at least comparative effectiveness (i.e. cells A1, A2 and B1) are those where the decision to adopt a new intervention is easiest. Based on the outcomes in this economic evaluation, the wobble board training program for preventing injury in high school basketball players would fall into cell C1 or C2. The statistical evidence for the program's effectiveness is weak and at this time, cell C2 appears as the most appropriate cell to place the wobble board program when considering all injury. Subsequently, the program would not be considered for funding at this time.

Still this matrix does not answer the question of funding consideration for the target of preventing acute injury in high school basketball players, as the program was more effective but more costly than the status quo (cell C1). In this case, a judgement call is required of the decision makers. Ultimately, the decision to implement such a preventative strategy towards decreasing injuries in high school basketball lies with the consideration of opportunity cost and allocative efficiency and is simply not a question that can be answered with this evaluation.

5.6 Conclusions

This study was able to quantify the cost of a balance training program in preventing injury in high school basketball players through a prospective randomized controlled trial. This is the only known study to present information on health care resource use, injury cost and the cost to prevent injuries in high school basketball athletes in Alberta. An IRF served as the data source for the resource tracking and cost valuation and was a reasonable method for such data collection.

The economic evaluation of the RCT demonstrated that the current practice for injury prevention in high school basketball (i.e. the status quo) was less expensive and marginally as effective as the balance training program. In the case of acute onset injuries, the balance training was more effective but was also more expensive. Subsequently, this balance training program cannot be considered the most technically efficient option of the two strategies under evaluation. As the question of allocative efficiency cannot be answered in the scope or focus of this evaluation, the funder is left with a judgement call for a more expensive and questionably more effective program in regards to acute injury prevention. If there were unlimited resources for health care treatments in general, there would be no need for economic studies (Canadian Coordinating Office for Health Technology Assessment, 1997). However, resources are limited and inadequate to support all interventions. The quandary in this specific evaluation is in the effectiveness of the program, as it did demonstrate a trend towards injury prevention but the statistics did not support this as an 'effective' program. With additional issues relating to program compliance and serious ACL injury, it would not be responsible to proceed with funding for a balance training program that is more costly and not significantly more effective than the status quo.

Currently, approximately one percent of the annual Alberta health care budget is spent on health promotion and protection (Government of Alberta, 2006). To make sport injury prevention a fiscal priority, there will need to be evidence of cost-effective options.

5.7 Future Research

There is impetus to proceed with further research as to how to perhaps deliver such a program in a manner that facilitates better compliance for the adolescent population. Future consideration of a transition to a more comprehensive team-based program may result in greater compliance rates than with the comprehensive home-based component of this RCT. It is believed that greater compliance would demonstrate greater effectiveness of this intervention. Further investigation of similar injury prevention strategies with reports of greater effect may also assist in making this program more attractive to the target audiences. Evidence of a more effective intervention should impact (i.e. reduce) the cost per injury prevented, making a much stronger argument to support the implementation of balance training programs in high school basketball.

It should be considered that the balance training program of this evaluation is easily implemented. Balance boards are readily available, easily shared and the program is not difficult to teach or learn. It is feasible that coaches, rather than therapists, would be capable of presenting the instructions and overseeing the completion of the exercises over the season.

The goal of the economic evaluation was to provide evidence on the costs and impact of the balance training program to provide policy relevant information for decision-making about implementation of the program. Unfortunately, the outcome of this study does not support a recommendation to fund this program at this time. This is in part because issues remain regarding the compliance with the program. Further research on strategies to enhance compliance is needed to see whether the program can be effective in this population. Finally, the evaluation only considered short term costs for injuries in this population. Future evaluations, including decision analytic modelling, would benefit from long term reviews where osteoarthritis outcomes, chronic pain and other health burdens could be considered.

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Appendix A

Wobble Board Training Program Compliance Record

Wobble Board Training Program Completion Sheet

1. Name: ____________________________________

2. ID #

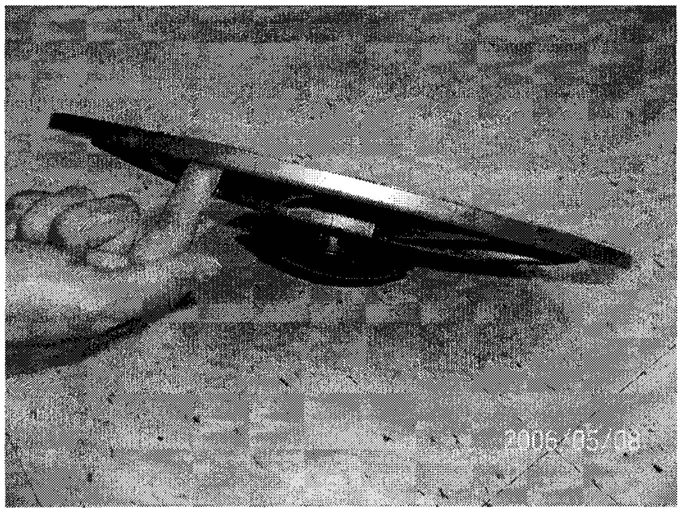
3. School:

Mark with a X in the appropriate box when you have completed your 20 minute daily balance training session using your wobble board.

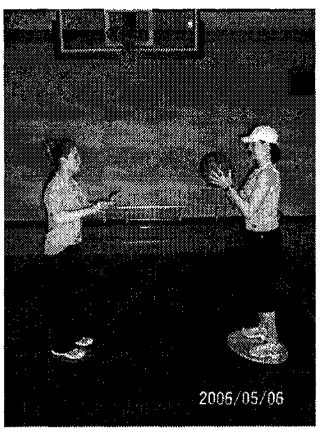
Week	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1							
2							
3							
4							
5							
6							
7							

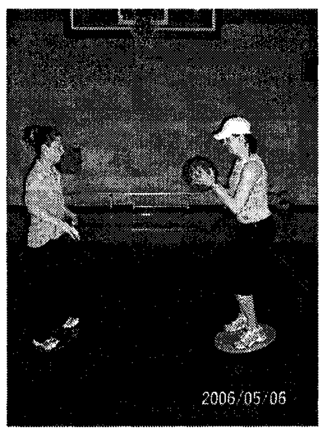
Appendix B

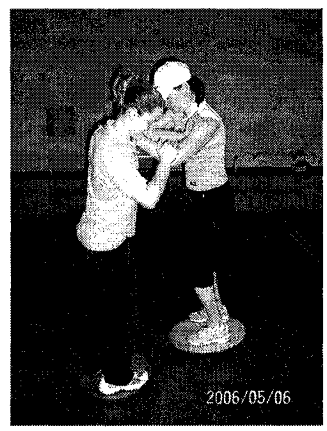
Team Based Sport Specific Component of Intervention Program

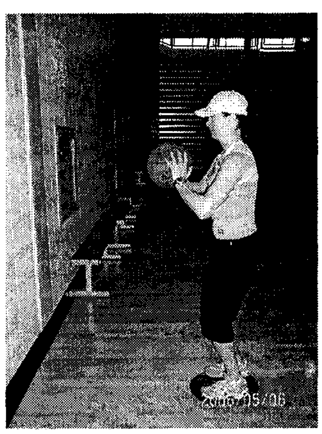


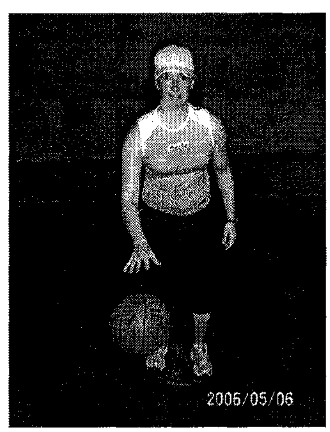
fitter first
balance and fitness for life





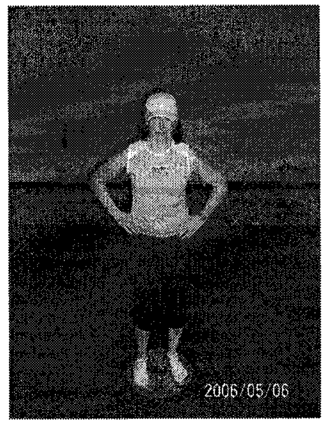






Appendix C

Home Based Component of Intervention Program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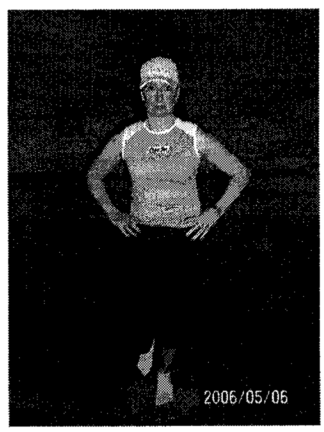
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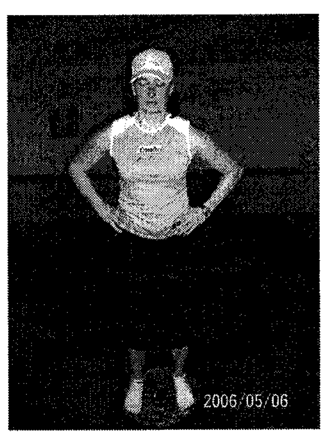
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Appendix D

Home Based Intervention Program Instructions

Six-Week Wobble Board Training Program

Warning: Wobble board should be used for prescribed training program only, by study participants only!

Expect each session to take 20 minutes. Complete training at least 5 times per week.
Wobble board should be used close to a wall or desk/counter top in order to steady yourself if necessary. However, minimal use of your arms is recommended to maximize the effects of the balance training program. You will be taught how to "stabilize" your trunk to maximize the benefit of the balance training program.
Contact study coordinator in the event of pain, discomfort or injury.

WEEKS 1 and 2:

1. Stand with feet parallel on the wobble board, knees slightly bent, and hands on hips as able. Move the front edge towards the floor, followed by the back edge. The edge should not actually touch the floor. Continue this movement repeatedly for 30 seconds. Rest for 5 seconds. Repeat this exercise 5 times.

2. Stand with feet parallel on the wobble board, knees slightly bent, and hands on hips as able. Move the left edge towards the floor, followed by the right edge. The edge should not actually touch the floor. Continue this movement repeatedly for 30 seconds. Rest for 5 seconds. Repeat this exercise 5 times.

3. Stand with feet parallel on the wobble board, knees slightly bent, and hands on hips as able. Move the front edge towards the floor, followed by the right edge, followed by the back edge, followed by the left edge. Continue this circulating movement for 30 seconds. Rest 5 seconds. Repeat this exercise 5 times in this clockwise direction followed by 5 times counterclockwise.

4. Stand with one foot centered on the wobble board, knees slightly bent, and hands on hips as able. Try to keep the wobble board level for 10 seconds. Rest 5 seconds. Repeat this exercise 10 times with each leg.

5. Stand with one foot centered on the wobble board as in 4, keeping the wobble board level for 10 seconds, but close eyes for the last 5 seconds. Rest 5 seconds. Repeat this exercise 10 times with each leg.

WEEKS 3 and 4:

1. As in 1 above but with one foot centered on wobble board. Continue this movement repeatedly for 15 seconds. Rest for 5 seconds. Repeat this exercise 5 times on each leg.

2. As in 2 above but with one foot centered on wobble board. Continue this movement repeatedly for 15 seconds. Rest for 5 seconds. Repeat this exercise 5 times on each leg.

3. As in 3 above but with one foot centered on wobble board. Continue this movement repeatedly for 15 seconds. Rest for 5 seconds. Repeat this exercise 5 times on each leg.

4. As in 4 above but try to keep the wobble board level for 20 seconds. Repeat this exercise 10 times with each leg.

5. As in 5 above but try to keep the wobble board level for 10 seconds with eyes closed throughout each repetition. Repeat this exercise 10 times with each leg.

WEEKS 5 and 6:

Same exercises as 1-5 in WEEKS 3 and 4 but change wobble board adjustment to level 2

Appendix E

Injury Report Form

UNIVERSITY OF CALGARY

INJURY REPORT FORM

Injury ID #:

Sport Medicine Centre

On this form, please report any injury (new or recurrent) occurring during basketball (game, practice or dryland training activity) which requires medical attention and/or results in the inability to complete the session of activity in which the injury occurred and/or requires you to miss at least one day of sporting activity. In completing this form feel free to get the assistance of a parent or coach. Please have any attending medical practitioner (physician, nurse, physiotherapist, athletic therapist) complete the appropriate section on page 3 of this form.

This form will be collected by your physiotherapist or athletic therapist
PLEASE DO NOT REMOVE FROM BINDER

1. Name:

2. Gender: ☐ Male ☐ Female

3. Study Subject ID #:

4. School:

5. Age Group: ☐ Junior ☐ Senior

6. Grade: ☐ 9 ☐ 10 ☐ 11 ☐ 12

7. Date of Birth: ____ / ____ / ____ (Day / Month / Year)

8. Date of Injury: ____ / ____ / ____ (Day / Month / Year)

9. This injury involved:
- ☐ **Sudden onset & contact with another player or equipment**
- ☐ **Sudden onset & NO contact with another player or equipment**
- ☐ **Gradual onset / overuse**
- ☐ **Unknown**

10. Injury Status:
- ☐ **New Injury**
- ☐ **Recurrence of injury from this year**
- ☐ **Recurrence of injury from previous year**

11. Was bracing or taping used on the injured area or limb at the time of injury?
☐ **Yes** ☐ **No** if <u>yes</u>, what type?

12. Injury occurred during:
- ☐ **Practice**
- ☐ **Game**
  - (a) ☐ *preseason* ☐ *regular season* ☐ *tournament* ☐ *playoff*
  - (b) ☐ *warmup* ☐ *1st half* ☐ *2nd half* ☐ *overtime*
- ☐ **Other Team Conditioning** (specify):

13. Position playing at the time of injury:
☐ **Centre** ☐ **Post** ☐ **Wing** ☐ **Point Guard** ☐ **Guard**

14. Was the player able to return to the same game or practice in which they were hurt?
☐ **Yes** ☐ **No**

15. Describe to the best of your ability the events surrounding the injury:

____

____

____

16. Was there a penalty called directly related to the injury event? ☐ **Yes** ☐ **No**

16a) If yes, what was the penalty?
☐ offensive foul ☐ defensive foul ☐ other

16b) If yes, what was the consequence of the penalty?
☐ free throw ☐ turnover ☐ removal from game

16c) If yes, who received the penalty? (check all that apply)
☐ injured player ☐ injured players team member ☐ opposing team player

17. Protective gear worn at the time of injury *(check all that apply)*:

- ☐ **Brace**
  if yes, specify: ☐ Knee ☐ Ankle ☐ Other*
  please describe:
- ☐ **Tape**
  if yes, specify: ☐ Knee ☐ Ankle ☐ Other*
  please describe:
- ☐ **Other Equipment** *(please describe)* **:**

18. Injury Location (*check all that apply, circle affected side where applicable*):

☐ Head	☐ Throat	☐ Hand (L / R)	☐ Pelvis	☐ Ankle (L / R)
☐ Face	☐ Shoulder (L / R)	☐ Finger (L / R)	☐ Hip (L / R)	☐ Foot (L / R)
☐ Ears (L / R)	☐ Collarbone (L / R)	☐ Back	☐ Groin (L / R)	☐ Toes (L / R)
☐ Eye (L / R)	☐ Upper arm (L / R)	☐ Side (L / R)	☐ Genitals	☐ Other*
☐ Nose	☐ Elbow (L / R)	☐ Ribs (L / R)	☐ Upper Leg (L / R)	
☐ Teeth	☐ Forearm (L / R)	☐ Chest	☐ Knee (L / R)	
☐ Neck	☐ Wrist (L / R)	☐ Abdomen	☐ Lower leg (L / R)	

***Please describe**

19.Type of Injury (*check all that apply to this injury*):

☐ Bruise	☐ Cut	☐ Dislocation	☐ Knocked out
☐ Burn	☐ Blister	☐ Broken bone	☐ Concussion
☐ Bleeding	☐ Joint swelling	☐ Muscle strain	☐ Other*
☐ Abrasion/Scrape	☐ Joint/ ligament sprain	☐ Tendonitis	

Please describe:

20. Total number of days you were unable to participate in your normal activities of daily living
(ie. Work, school, camp, other) ☐

21. Total number of days you were unable to participate in <u>any</u> sport due to this injury: ☐

22. Total number of days you were unable to participate in basketball: ☐

23. Total number of days (or hours) your parent or guardian missed work as a direct result of your injury: ☐ days ☐ hours

24. Did you see any health care professional(s) for assessment or treatment of this injury?

☐ Physician (Family)	(Total # visits ____)	☐ Massage therapist	(Total # visits ____)
☐ Physician (Specialist)	(Total # visits ____)	☐ Dentist	(Total # visits ____)
☐ Physiotherapist	(Total # visits ____)	☐ Chiropractor	(Total # visits ____)
☐ Athletic Therapist	(Total # visits ____)	☐ Other*	(Total # visits ____)

Please specify:

25. Did you receive any other treatment for this injury? ☐ Yes ☐ No
(if yes, please check all that apply. Be as specific as possible, including location of service provided)

☐ First Aid	☐ Cast	☐ Crutches	☐ Surgery	☐ Other*
☐ Xrays	☐ Brace	☐ Taping	☐ Medications	

Describe:

26. Who provided you with clearance to return to activity?

☐ Self	☐ Coach	☐ Physician
☐ Parent	☐ Therapist	☐ Other*

Please specify:

ASSESSMENT

Date of Assessment: ______/______/______
Day Month Year

Patient's specific complaint:

History (including any previous injury to structure(s):

Observation:

Functional Tests:

Special Tests:

Palpation:

Impression/Assessment: ____
Side Region Type of Injury (i.e. Rt AC Joint- 2degree sprain)

SMC Diagnostic Code(s):

1	
2	
3	

Comments:

Assessor's signature:

Appendix F

Cost Valuation Methods

The methods for assigning costs for each type of health care service and/or product that was reported on any IRF are discussed in detail below. The actual monetary value designated for the resource was accepted as the opportunity cost.

Physician visits

Physician costs for all fee-for-service visits were determined using the billing codes from the Alberta Health Care Insurance Plan (AHCIP) Medical Price List, October 2004 schedule. The appropriate billing codes were determined through consultation with numerous billing coordinators, physicians that perform the specific services, as well as two external physician billing companies.

Physician costs that were calculated using AHCIP codes include family physician and orthopaedic surgeon office visits, emergency medicine physician consults at a hospital, orthopaedic surgeon fees for surgery and castings, surgical assistant (physician) time, and anaesthetist fees for surgery.

An initial visit to a physician was costed with a consultation fee (where applicable) and future visits were costed with a follow-up visit fee. Differential charges were calculated depending on type of practitioner (i.e. family physician versus specialist). Of note, visits to the study sport medicine physician at the University of Calgary Sport Medicine Centre referred directly from the study physiotherapists or Certified Athletic Therapists were billed, and subsequently costed as a complex visit (AHCIP code 03.04A), as billing for a consultation requires physician referral. Initial visits to other sport medicine physicians at the

University of Calgary Sport Medicine were costed as a consultation (AHCIP code 03.08A).

Wherever a specialist visit was noted, the appropriate billing codes and charges were accessed for that specialty (e.g. orthopaedics, emergency medicine) and a relevant specialist physician provided expert opinion on the most common billing code(s) for the population and injury.

Emergency room physician fee-for-service rates are based on the time of day of the visit. As most high school basketball practices and games take place after school and therefore injuries resulting from these activities would occur in that time frame, the evening/weekend fee was applied for emergency room visits (AHCIP code 03.05DR).

Radiologist fees for imaging services that occurred outside a Calgary Health Region (CHR) ambulatory care centre were accounted for in the fees for diagnostic imaging because the AHCIP fee is inclusive of physician fees. Cost estimations for emergency department visits, provided by CHR, accounted for radiologist salaries for imaging services that occurred within a CHR ambulatory care centre.

Emergency department visits

The costs associated with an outpatient-based (i.e. ambulatory care) emergency department visit at a CHR hospital were obtained from the Case Costing Department within Financial Services of the Calgary Health Region. Outpatient costs were obtained because there were no known cases of hospital admittance with an emergency department visit in the study. Costs were based on Alberta Children's Hospital data, as this is the only emergency department that the CHR currently costs. Ambulatory care visits in the fiscal year 2004/2005 for individuals 12 to 18 years of age that were a result of a sport injury were extracted from the Case Costing Department database. The costs were reported to be inclusive of the salaries of technical and medical staff associated with an emergency department visit, as well as supplies, maintenance and other overhead costs. Diagnostic imaging and lab costs were reported separately. Overall, costing procedures were reported to follow specific costing guidelines for Alberta (D. Schulli, personal communication, June 5, 2006) but the formal costing procedures were not provided.

The data provided by CHR was stratified by injury type, wherein a mean cost was calculated from the aggregate cost of the specific injury visits divided by the number of visits. Cost valuation excluded diagnostic imaging and lab fees when IRFs did not indicate such a service occurred. Emergency room physician fees were accounted for separately, as previously described. The costs of emergency department visits were considered as a cost borne by the publicly funded health care system.

Surgery

All players reporting surgical intervention as a result of an injury sustained in basketball had anterior cruciate ligament (ACL) sprains (n=7). Fee-for-service costs were calculated for the orthopaedic surgeon, surgical assistant and anaesthetist based on the AHCIP October 2004 schedule. Orthopaedic surgeons are paid by the surgical procedure they perform and a specific billing code(s) is sent to AHCIP to receive payment. Surgical assistants are paid by time. Based on physician consultation, an average ACL surgery (AHCIP code 93.45D) is reasonably allotted 1.5 hours in duration. The surgical assistant is paid $138.46 (AHCIP code 93.45D) for this time period. The anaesthetist is paid a flat rate based on the surgical procedure or is paid by time, whichever is more. In consideration of the above noted surgery duration and specific procedure, the anaesthetist fees were determined as $331.12 (AHCIP code 93.45D ANE).

Additional data regarding surgical costs were obtained from Quality, Safety and Health Information of the Calgary Health Region. Currently, day surgeries in the Calgary Health Region are only costed at Rockyview General Hospital. Data was extracted for all ACL surgeries (93.45D) performed on patients 18 years and younger in the fiscal year 2004/2005 at the Rockyview Hospital. The costs were inclusive of operating room, recovery room and any diagnostic imaging costs as well as staff salaries, supplies, and overhead costs. Again, costing procedures were reported to follow specific costing guidelines for Alberta (D. Schulli, personal communication, June 5, 2006) but the formal costing procedures were not provided.

The mean cost provided by the CHR was added to the fee-for-service costs to determine the average cost of ACL surgery. The average cost of an ACL surgery was determined as $4947.91 (range $4269.24 - $5929.74).

Surgery costs were considered as a cost borne by the publicly funded health care system.

Physiotherapy

Players who reported physiotherapy visits as a direct result of their basketball injury were allotted an initial consultation fee at the rate designated in the Alberta Physiotherapy Association Fee for Service Guidelines ($88.00). All subsequent visits were based on the treatment fee also designated by the Alberta Physiotherapy Association ($44.00). Assessment and treatment fees for 10 different physiotherapy clinics across the city of Calgary and one clinic in each outlying centre where a study school was located were collected. It was assumed that all visits were at the rate of a private visit, indicating that the player paid out of pocket (with potential extended health care insurance reimbursement). Most sporting injuries are not covered by the CHR, which allots different (lower) fees and not all physiotherapy clinics receive CHR funding.

Athletic Therapy

Players who reported athletic therapy visits as a direct result of their basketball injury were allotted an initial consultation fee at the mid-range price designated in the Canadian Athletic Therapists Association Private Practice Recommended Fee Guidelines ($57.50). All subsequent visits were calculated based on the treatment fee also designated by the Canadian Athletic Therapists Association Private Practice Recommended Fee Guidelines at the mid-range price ($47.50). Athletic therapy is not covered by the provincial or regional health authorities and therefore was considered as a cost not borne by the publicly funded health care system.

Massage Therapy

There are no specific billing guidelines for massage therapists in the province of Alberta. Subsequently, massage therapy treatment costs were determined from the mean cost for a 60 minute session from rates provided by 10 different massage therapy centres across the city of Calgary and one massage therapy centre per location where a study school was involved. Massage therapy is not covered by the provincial or regional health authorities and therefore was considered as a cost not borne by the publicly funded health care system.

Chiropractic

Players who reported chiropractic visits as a direct result of their basketball injury were allotted an initial consultation fee at the rate recommended by the College of Chiropractors of Alberta ($60.00). All subsequent visits were based on the treatment fee also recommended by the College of Chiropractors of Alberta ($35.00). Individuals with AHCIP coverage are eligible for $200.00 of chiropractic treatment annually (from July through June) at a maximum of $13.23 per visit (AHCIP code B520). It was assumed that all individuals would be eligible for the AHCIP portion coverage as all participants were residents of

Alberta. According to the College of Chiropractors of Alberta, the fees within the Recommended Fee Schedule (2003) include the charges billable to AHCIP and as such, in the evaluation the fees were split to allot the appropriate cost to AHCIP and the cost to patient or extended health care provider.

Acupuncture

One player reported treatment from two different acupuncturists. The fees for these treatments were provided by the player and were considered as a cost not borne by the publicly funded health care system.

Other practitioners

The injury report form also allotted for treatment by a dentist and "other". No players reported treatment by a dentist. One individual reported a consultation with a homeopathic doctor. The fee paid for this visit was provided by the player and was considered as a cost not borne by the publicly funded health care system.

X-rays

Generally, the fees for x-rays billed to AHCIP are inclusive of the cost of the x-ray itself, as well as the reading fees of the radiologist and associated personnel costs. The exception to this is x-rays that are performed as part of an ambulatory care visit at a CHR centre, such as the hospital. These x-rays are not billed to AHCIP and were accounted for in emergency department visit costing, as appropriate.

Consultation with an x-ray technician regarding a norm of billing for each injury that required an x-ray was used in determining the costs of x-ray services. The billing code was identified and the appropriate fee for that billing code was accessed from the AHCIP Medical Price List, October 2004 schedule. The appropriate fee was then applied to the respective number of x-rays for each injury to determine total costs due to x-ray services. Individuals who reported an emergency room visit and x-ray were instead costed with an ambulatory care visit as provided by the CHR. X-ray costs were considered as a cost borne by the publicly funded health care system.

Magnetic Resonance Imaging (MRI)

Subsequent to physician consultation, it was determined that public access to the MRI scan was most likely. The costs associated with a discrete MRI visit obtained through the public health care system were obtained from the Case Costing Department within Financial Services of the Calgary Health Region. The weighted mean was calculated based on the cost per centre and the number of scans performed annually. Costs are inclusive of salary of technical and medical staff associated with the provision of a MRI, as well as maintenance and other overhead costs. Overall, costing procedures were reported to follow specific costing guidelines for Alberta (D. Schulli, personal communication, June 5, 2006) but the formal costing procedures were not provided. The weighted mean cost of a discrete MRI within CHR is $474.00. MRI costs were considered as a cost borne by the publicly funded health care system.

Computed Tomography (CT) scan

After physician consultation, it was determined that public access to the CT scan was most likely. The costs associated with a discrete CT scan obtained through the health care system were obtained from the Case Costing Department within Financial Services of the Calgary Health Region. The weighted mean was calculated based on the cost per centre and the number of scans performed annually. Costs included salary of technical and medical staff associated with the provision of a CT scan, as well as maintenance and other overhead costs. Again, costing procedures were reported to follow specific costing guidelines for Alberta (D. Schulli, personal communication, June 5, 2006) but the formal costing procedures were not provided. The weighted mean cost of a discrete CT scan within CHR is $296.00. CT scan costs were considered as a cost borne by the publicly funded health care system.

Bone scan

With consideration of the injuries that prompted bone scan investigation, physician and nuclear imaging technician consultation concluded that AHCIP code X157 was most appropriate for this costing. The fee for this diagnostic imaging procedure is $334.56 and is inclusive of the exam itself and the reading fees of the radiologist. Bone scan costs were considered as a cost borne by the publicly funded health care system.

Casting/Splinting

Casting is provided exclusively in-hospital in the CHR, with the exception of the University of Calgary Sport Medicine Centre, and a few community care centres. Casting or splinting performed in conjunction with an ambulatory care visit to a hospital emergency department is included in the costing of the emergency room visit. Additionally, discrete casting and splinting visits are not specifically costed within the CHR nor Alberta Health and Wellness but rather are grouped in a category known as an ambulatory care classification system (ACCS) cell. ACCS cell data far exceeded reasonable fees for casting and splinting of the simple fractures sustained during the study and as such, cost valuation for casting was determined from a number of sources including University of Calgary Sport Medicine Centre patient-payable fees, fee-for-service physician consultations, fracture reduction, associated anaesthetics and x-ray fees specific to the type of fracture. Contact was made with all players who reported fractures and casting/splinting. Assumptions regarding type of reductions and the subsequent AHCIP codes were made based on the fracture information received from the players or parents. For the initial visit players were costed with an emergency visit, if reported on the IRF, as well as a patient-payable cast charge specific to the location of the injury, x-ray(s) as reported on the IRF and fee-for-service charges for the emergency physician consultation, the fracture reduction and an associated anaesthetic. Future visits, including orthopaedic consult, x-ray(s) and recasting were costed as reported on the IRF.

Stitches

Stitches were reported to have been provided at emergency room visits. The provision of stitches is within the ambulatory care visit fee provided by CHR and therefore no additional fee was attached to this procedure.

Crutches

Subsequent to consultations with a hospital inpatient physiotherapist, cast clinic nurse, and emergency room nurse, it was their common opinion that crutch purchase was more likely than crutch rental. The fee for crutch purchase was obtained from the Calgary hospitals as $26.00. Crutch costs were considered as a cost not borne by the publicly funded health care system.

Bracing

Braces were costed for patellofemoral pain syndrome (PFPS), medial collateral ligament (MCL) and ACL sprains, ankle sprains and wrist strain/sprains. Cost valuation of braces was determined from Calgary and area retailers, including physiotherapy clinics, orthotics companies, bracing stores and pharmacies. Retailers were asked to identify the two most popular products for each specific condition and to provide the respective prices of those two products. Not all retailers carried bracing products for all conditions. The mean cost of a brace for each condition was then calculated from the prices provided. Brace costs were considered as a cost not borne by the publicly funded health care system.

Aircast walking boot

The price for an Aircast walking boot was obtained from 11 Calgary and area retailers, including orthotics centres, physiotherapy clinics, pharmacies and Calgary hospitals. The mean cost of a walking boot was subsequently calculated from these retail prices. Walking boots were considered as a cost not borne by the publicly funded health care system.

Orthotics

One individual reported the purchase of orthotics as an intervention for an injury within the study. The actual cost of the orthotics was obtained from the parents of the player. Orthotic costs were considered as a cost not borne by the publicly funded health care system.

Tensor

The price of purchase for a 3-inch tensor bandage was obtained from 12 Calgary and area retailers, including orthotics centres, physiotherapy clinics, pharmacies and the Calgary hospitals. The mean cost of a tensor was calculated from these retail prices. Tensor costs were considered as a cost not borne by the publicly funded health care system.

Sling & Swathe

In the case of the Sling & Swathe (Figure 8 brace), it was assumed that this was purchased directly from the hospital. The purchase price for the Figure 8 brace through the Calgary hospitals is $20.00. Figure 8 brace costs were considered as a cost not borne by the publicly funded health care system.

First Aid

Although first aid was a treatment recorded on the IRF, its provision was inclusive of rest, ice, compression and elevation. Ice was accounted for separately and rest and elevation were determined as no cost. Compression, if applied, may have included use of a tensor bandage which was also accounted for separately. As such, the identification of first aid as a treatment did not result in an additional cost for the calculation of direct health care costs in this evaluation.

Medication

Although medication was a treatment recorded on the IRF, insufficient information (such as type of medication, duration of intake, quantity of intake) was tracked on the IRF. Subsequently, medication costs were not directly calculated in the economic evaluation. It is important to note that some medication costs may be accounted within ambulatory care visit costs and day surgery costs, where the cost of medication dispensed was built into the costs provided from the Calgary Health Region.

Taping

Although taping was a treatment recorded on the IRF, insufficient information (such as supplies used, duration of tape application, cost for tape application services) was tracked on the IRF. Subsequently, taping costs were not estimated or included in the economic evaluation.

Ice

The provision of ice was determined as no cost.

Appendix G

Intervention Program Costs

Intervention costs for this injury prevention study included the cost of wobble boards for all individuals, the cost of instruction of the program to the players by a physiotherapist or Certified Athletic Therapist, and the cost of the home program handout.

In total, 710 wobble boards were distributed to the intervention group – one wobble board per player for the home program portion and additional boards for each school so that the pre-practice routine could be performed. The Fitter®first Classic Balance Board retails for $39.95(CAD). The total cost for the wobble boards was calculated at $28,364.50 ($39.95 x 710). To determine a mean cost per player, this value was divided by the number of individuals in the intervention group (n=494). The mean cost of a wobble board per player was $57.42.

The average time allotted for the physiotherapist or Certified Athletic Therapist to teach the program to a school was two hours. Each therapist was paid $20.00 per hour. The total cost for teaching of the program to all players in the intervention group was $520.00. To determine a mean cost per player, the total cost was divided by the number of individuals in the intervention group (n=494). The mean cost of teaching of the program per player was $1.05.

The total cost for photocopying of the home program handouts was $83.98, resulting in a mean cost of $0.17 per player.

Overall, the mean cost of the intervention was $58.64 per player.

Appendix H

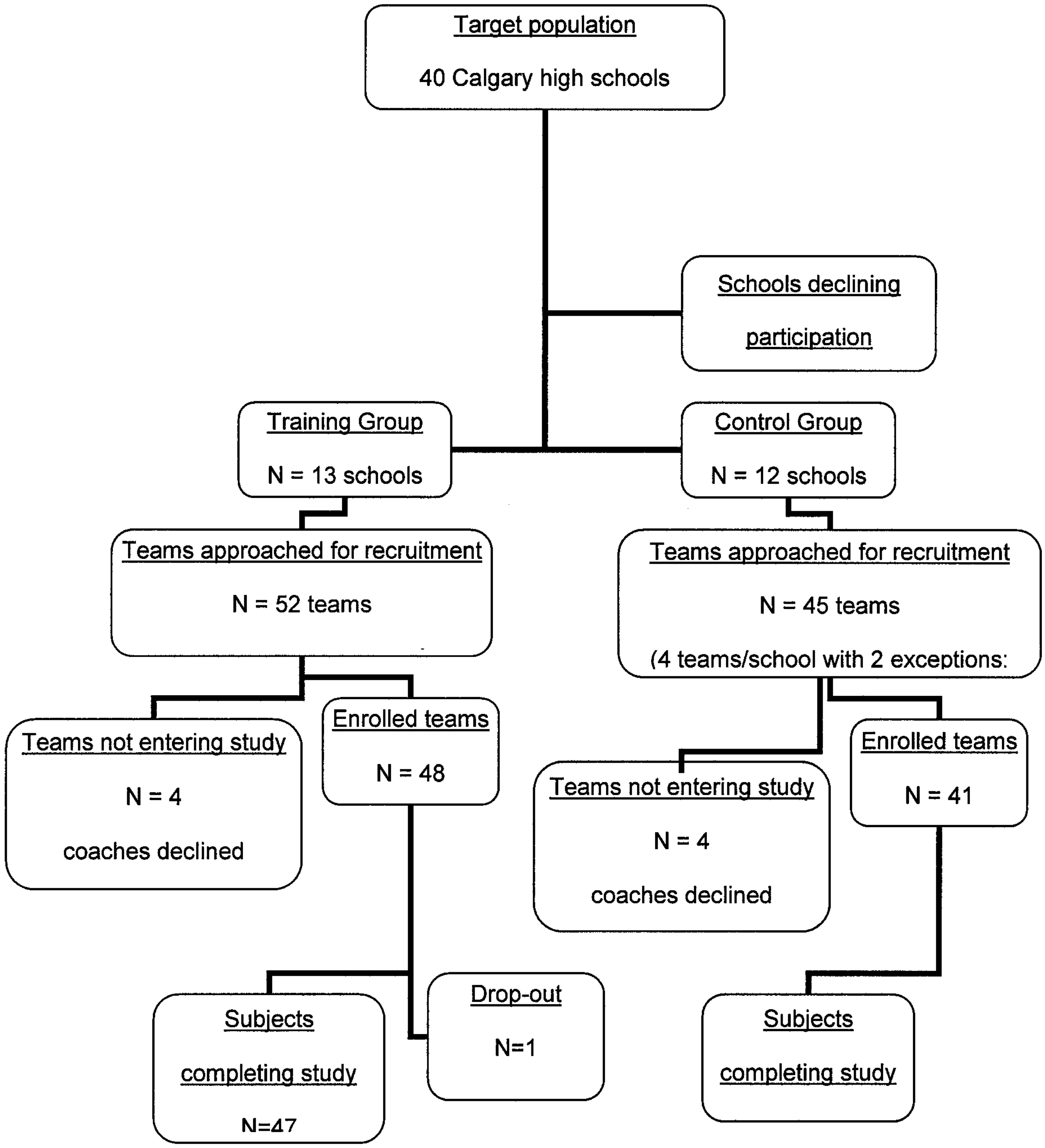
Variables and Costs Ranges in the Analysis of Extreme

Health Care Service	Primary Value	Low Value	High Value
Physiotherapy consultation	$88.00	$60.00	$90.00
Physiotherapy treatment	$44.00	$40.00	$55.00
Athletic therapy consultation	$57.50	$45.00	$70.00
Athletic therapy treatment	$47.50	$35.00	$60.00
Chiropractic consultation	$46.77	$20.00	$100.00
Chiropractic treatment	$21.77	$10.00	$35.00
Massage	$57.45	$46.73	$74.77
ACL surgery	$4947.91	$4269.24	$5929.74
ER visit (ankle sprain)	$175.76	$103.07	$232.35
ER visit (knee injury)	$195.32	$103.07	$236.36
ER visit (hip strain)	$198.67	$103.07	$539.92
ER visit (forearm fracture)	$342.97	$103.07	$801.96
ER visit (finger fracture)	$174.92	$103.07	$232.35
ER visit (finger sprain)	$110.31	$103.07	$200.26
ER visit (concussion)	$154.68	$103.07	$455.69
ER visit (abdominal injury)	$129.50	$103.07	$190.20
ER visit (tongue laceration)	$168.17	$103.07	$455.69
ER visit (clavicle fracture)	$221.26	$143.18	$495.80
ER visit (facial laceration)	$149.97	$103.07	$455.69

Product	Primary Value	Low Value	High Value
ACL brace	$1,344.88	$1,143.00	$1,450.00
MCL brace	$382.70	$80.68	$900.00
Other knee brace	$85.41	$39.92	$161.00
Ankle brace	$71.75	$46.73	$109.00
Wrist brace	$34.46	$29.00	$45.00
Aircast boot	$156.77	$102.00	$195.00
tensor	$4.37	$0.93	$8.50
Intervention program	$58.64	$29.97	$87.46

Appendix I

Flow Chart of RCT Study Enrolment


Target population
40 Calgary high schools
Schools declining
participation
Training Group
N = 13 schools
Control Group
N = 12 schools
Teams approached for recruitment
N = 52 teams
Teams approached for recruitment
N = 45 teams
(4 teams/school with 2 exceptions:
Teams not entering study
N = 4
coaches declined
Enrolled teams
N = 48
Teams not entering study
N = 4
coaches declined
Enrolled teams
N = 41
Subjects
completing study
N=47
Drop-out
N=1
Subjects
completing study

Appendix J

Baseline Characteristics of RCT Study Participants

Baseline Characteristic	Intervention Group n=494 (95% CI)	Control Group n=426 (95% CI)
Age in years (median)	16, range 13-18	16, range 12-18
Gender		
Female	50.6%	48.4%
Male	49.4%	51.6%
Injury in the previous year	37.3% (31.6–43.0)	38.4% (33.1–43.7)
Height (m)	1.75 (1.73-1.77)	1.75 (1.72-1.77)
Weight (kg)	65.9 (64.0–67.7)	66.4 (64.0-68.8)
Body Mass Index (kg/m^2)	21.5 (21.1-21.8)	21.7 (21.2-22.1)
Vertical Jump (cm)		
Female	38.4 (36.6-40.2)	36.8 (34.7-38.9)
Male	53.4 (51.4-55.3)	53.2 (51.0-55.5)
Predicted VO_2Max (ml/kg/min)		
Female	37.7 (35.1–40.4)	37.3 (35.8–38.8)
Male	47.0 (45.1–48.9)	45.2 (42.9-47.5)
Left Handed	8.9% (3.6–8.8)	6.2% (5.2-12.7)
Single leg balance (s)	5.2 (4.9–5.7)	5.2 (4.8–5.5)

Appendix K

Incremental* Costs and Cost per Player Outcomes of the Intervention Program

Cost scenario	NNT	Public Payer Perspective	Cost to prevent one injury	AHW Perspective	Cost to prevent one injury
Mean cost per player	15	$133.36	$2000.40	$117.81	$1767.15
Males	11	$80.02	$885.06	$77.64	$854.04
Females	24	$181.84	$4364.16	$155.36	$3728.64
Lower Extremity	22	$129.45	$2847.90	$116.73	$2568.06
Ankle Sprains	19	$51.96	$987.24	$59.29	$1126.51
Acute	11	$126.49	$1394.69	$116.16	$1277.76

* = intervention group – control group

Appendix L

Cost differences* for mean cost of injury

between the intervention and control groups

Cost scenario	Public Payer Perspective	AHW Perspective
Cost of injury per injured player	$337.55	$247.78
Males	$163.52	$118.87
Females	$408.28	$307.70
Lower extremity	$381.75	$291.41
Ankle sprains	$0.01	$20.27
Acute	$396.08	$297.08

* = intervention group – control group

Appendix M

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Department of Paediatrics

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August 28, 2006

Dear Ms. McAllister,

Thank you for requesting permission to reproduce in your Master of Science thesis at the Universtiy of Calgary the figure "Effectiveness-cost matrix for comparison of new treatment with current care" from our article entitled "Cost effectiveness analysis in health care: contraindications" which was published in the BMJ in 2002;325:891-894 (19 October).

I have consulted with my co-authors, and on behalf of myself and my co-authors, I grant you permission to reproduce this figure, with appropriate attribution, in your Masters thesis.

Yours sincerely,

Gillian Currie, PhD
Assistant Professor
Department of Paediatrics
Department of Community Health Sciences

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