

THE ROAD TO PARASPORT EXPERTISE: EXAMINING THE EXISTING PARASPORT
DEVELOPMENT LITERATURE AND CURRENT WHEELCHAIR BASKETBALL
PLAYERS' DEVELOPMENTAL TRAJECTORIES

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ABSTRACT

Unfortunately, research regarding development of athletes with disabilities has not kept pace with the tremendous growth of the parasports. The purpose of this thesis was to examine athletes with disabilities' developmental trajectories and the training-related factors that led to expertise. A systematic literature review was performed in phase I to synthesize the existing studies exploring aspects of development of athletes with a disability. The lack of studies examining such factors facilitated second phase of the thesis, which explored developmental trajectories and training histories of athletes training at the Wheelchair Basketball Canada National Academy. Although athletes illustrated a similar developmental pattern (i.e., milestones, training modifications) as they progressed through their sporting career, there were disability-related differences (i.e., whether disability was congenital or acquired influenced onset of certain milestones). This thesis contributes to a limited literature base and provides direction for future research regarding development of athletes with disabilities.

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Chapter One: General Introduction

Parasport has undergone tremendous growth since its inception. Believing that physical activity and sport could promote positive identity, confidence and social connections among paraplegic patients, Dr. Ludwig Guttman founded the National Spinal Injury Centre in 1944 at the Stoke Mandeville Hospital in Great Britain, focusing on recreational and competitive sport rehabilitation for injured veterans. Dr. Guttman held a festival in 1948 called the Stoke Mandeville Games in which 16 patients competed in an archery game (Gold & Gold, 2007). These games took place on the same day as the opening ceremonies of the 1948 Olympics, symbolizing Dr. Guttman's belief that such games had the potential to become an international event where the abilities of paraplegic athletes could be celebrated (Gold & Gold, 2007). In 1952, injured servicemen from Netherlands joined the Games and the International Stoke Mandeville Games were founded.

From these modest origins, the 1960 Games in Rome (400 athletes from 23 countries) and 1964 Games in Tokyo (357 athletes from 21 countries) began to establish parasport within the domain of high performance sport with the event becoming known as the Paralympic Games. The word 'Paralympics' originated from the Greek word 'para' meaning 'beside' or 'alongside' and 'Olympics' which reflects the approach that the Paralympics run parallel to the Olympics, highlighting the coexistence of both movements (Gold & Gold, 2007). Continued growth of parasport, including the introduction of the Winter Paralympics in 1976, which permitted participation of visually impaired and amputee athletes and the 1980 Games in Arnhem, which opened doors for athletes with cerebral palsy, led to the creation of the International Paralympics Committee (IPC) in 1989. The IPC, comprised of 162 National Paralympics Committees, subsequently created an 11 point mission focused on "sport development from initiation to elite level" (Gold & Gold, 2007). From international games with a few hundred athletes from

approximately 20 countries in the 1960s, recent international games, such as the London 2012 Games, now feature thousands of competitors from over 100 countries, involving athletes with a range of physical disabilities including but not limited to impaired muscle power (e.g., paraplegia, muscular dystrophy), leg length difference, impaired passive range of movement, limb deficiency (e.g., amputation), and vision impairment (Murdock, 2012).

Despite this increased international participation, there has been limited focus by researchers on issues of development in parasport. The lack of awareness and understanding regarding the unique developmental concerns of athletes with disabilities has left this population with limited resources. Athletes with disabilities, much like mainstream sport athletes, require relevant sport-specific training programs to enhance their skill acquisition. While some findings from the mainstream sport literature can be generalized to athletes with disabilities, other factors may vary due to disability-related issues. For example, the influence of various forms of practice (e.g., Helsen, Starkes, & Hodges, 1998), and the various processes of skill acquisition (e.g., Baker & Young, 2014) on successful development could arguably be generalized to both cohorts. However, other factors such as differences between the need and opportunity for early specialization and diversification (e.g., Baker, Cobley, & Fraser-Thomas, 2009) or the age of transition between stages of development (e.g., Côté, 1999) may vary when disability issues (e.g., was the disability congenital or acquired) and related barriers (e.g., accessibility and opportunity) are considered.

Further, numerous developmental models have emerged regarding mainstream sport athletes pathway to expertise. Bloom (1985) postulated that children advance through three main stages of development in which child's parents and mentors (i.e., teacher, coach) play critical roles in child's development. Parents' and mentors' behavior combined with the child's response

to the environment are determinants of successful domain-specific skill acquisition and greater progression to expertise. Gagné (1985; 2015) suggested that kids are driven toward the domain-specific activities based on their natural abilities. These natural abilities are manifested from biological predispositions coupled with the influence of environment and interpersonal catalysts. The appropriate setting in which these natural abilities can be fostered leads to the child developing domain-specific skills, which Gagné refers to as ‘giftedness.’

Contrary to Gagne’s idea of predispositions, Ericsson and colleagues (Ericsson, Krampe, & Tesch-Römer, 1993) emphasized the role of training in an individual’s ability to acquire and maintain skills and perform on the competitive stage. One of the tenets of this framework is that the type of practice (i.e., deliberate practice) is extremely important to the success of the child. Deliberate practice must be cognitively and physically effortful and is often not enjoyable. The monotonic relationship implies that the earlier the child engages in practice, the greater total accumulated hours of practice and therefore, the greater the likelihood of attaining expertise. However, there are concerns regarding this approach and the negative psychological consequences of specialization at an early age (see Baker et al., 2009). Côté (1999) argued that early specialization is not the only route to expertise and that optimal development comes when children progress through three stages; during childhood, children diversify their experiences in multiple sports. The assumption here is that the general cognitive and motor skills acquired through sporting experiences can be transferred into the desired sports during the second stage; specialization. During adolescence, the athletes narrow their efforts into fewer sports, while increasing training intensity. In the investment years, athletes devote all their efforts and resources into one sport with objective of becoming experts.

Contrary to the aforementioned views, Wylleman and colleagues (Wylleman, Alfermann, & Lavallee, 2004) argued that the child and their immediate environment are not the only catalysts to the child's development. They highlighted the role of the societal structure (culture, societal beliefs, team's history) on athletes' development and ultimately, expertise. Despite the disparity between models, what is clear is that there has been considerable research attention devoted to examining athlete development in mainstream sports. In contrast to the mainstream sport literature, there is a lack of available training programs tailored to meet the needs of athletes with disabilities (Bednarczuk, Rutkowska, & Skowronski, 2013). Therefore, athletes with a disability and coaches rely heavily on trial and error to make training adjustments accordingly (Liow & Hopkins, 1996). Hence, it is important to have a more complete understanding of the unique developmental and performance factors that are associated with athletes' disabilities (e.g., acquired vs. congenital).

The purpose of this thesis was to examine athletes with disabilities' developmental trajectories and training-related factors that led to expertise. The thesis is twofold; first, a systematic literature review was conducted to synthesize all available studies that explored aspects of athletes with disabilities' development and to identify gaps in the literature. This literature review facilitated phase II of the thesis, the objective of which was to obtain a better understanding of athletes with disabilities' developmental pathways on the way to expertise. More specifically, I examined differences in the developmental trajectories and training histories between athletes with congenital and acquired disabilities who were training with Wheelchair Basketball Canada National Academy.

Chapter Two:

A Systematic Review of Influences on Development of Athletes with Disabilities

This manuscript has been submitted for review at Adapted Physical Activity Quarterly and is presented in its submitted form. All references for this manuscript are presented in Chapter 5.

Summary

Compared to mainstream sport athletes, relatively little is known regarding the factors affecting the development of athletes with a disability. Sport-specific training programs are essential to athletes' successful performance and in order to create appropriate programs and strategies, a clear understanding of the nuances of development of athletes with a disability is important. The objective of this systematic review was to synthesize existing research on development in athletes with a disability and examine the key determinants of successful development and sporting performance. After searching the Web of Science and SportDiscus databases, 21 articles were identified that met the inclusion criteria, which were assessed using the Mixed Methods Appraisal Tool and categorized into two groups: 'Training, Practice and Conditioning' and 'Long-Term Development.' Amongst the studies identified, there was a disproportionate focus on training, practice and conditioning (16 of 21 studies focused on immediate interventions and training programs to enhance performance in practice and competition), and less on skill acquisition and long-term development (i.e., physiological and psychosocial changes from long-term practice). The review reflected a lack of research on sport-specific development of athletes with a disability, which raises concerns regarding the effectiveness and appropriateness of current training practices.

Introduction

Parasport has undergone tremendous growth over the past half century - from 400 athletes from 23 countries in 1960 to the recent London 2012 Games that featured several thousand competitors from over 100 countries (Murdoch, 2012). Further, the Rio 2016 Paralympic Games is estimated to attract 4,350 athletes from more than 160 countries competing in 526 events in 22 different sports ("Rio 2016," n.d.). The growth of participation in parasport is reflected in the sport science literature where emerging investigations into athletes with a disability now include topics such as stress and coping mechanisms (Campbell & Jones, 2012), motivation (Wu & Williams, 2001), athletic identity (Huang & Brittain, 2006) and comparisons of psychological traits to mainstream sport athletes (De Guast, Golby, Van Wersch, & d'Arripe-Longueville, 2013). Physical performance of athletes with a disability has also been investigated in individual and team sports, including analyses of stroke patterns in swimming (Daly, Djjobova, Malone, Vanlandewijck, & Steadward, 2003) and kinematics and mechanics of shooting in wheelchair basketball (Goosey-Tolfrey, Butterworth, & Morriss, 2002). In addition, the interaction between athletes with a disability and their equipment (i.e., wheelchair, prosthesis) has also been examined with the aim of identifying optimal methods (e.g., angle of propulsion) to maximize performance (Burkett, Mellifont, & Mason, 2010).

However, while this research has contributed to understanding aspects of performance and competition, there is a comparatively limited understanding of the *development* of athletes with a disability. Within the context of this paper, development was defined as the process of skill acquisition and sport-related development necessary to progress to elite level of competition. More specifically, studies had to examine trajectories, training modifications,

competition or recovery processes throughout sporting career of athletes with a disability from their introduction to sport through all phases on the road to expertise (defined as competing at the highest level of competition in their particular sport such as national or international competitions). While some past research has examined developmental factors in athletes with a disability such as practice history (Oudejans, Heubers, Ruitenbeek, & Janssen, 2012) and physical adaptation to training (Huonker et al., 1998), the objectives of these studies were not directly tied to the understanding of developmental factors necessary for performance in parasport (i.e., developmental factors were assessed as by-products rather than predicting variables).

Considering the significant growth in the literature on athlete development and expertise in mainstream sport individuals over the past two decades, it is clear that research on development of athletes with a disability has not kept pace. However, in order to provide coaches and parasport athletes with appropriate recommendations for optimizing their training environments, it is essential to attain a thorough understanding of the unique factors affecting development and performance (e.g., training history, practice routines, milestones) over time. On the one hand, there are obvious similarities between research with mainstream sport and parasport. In recent decades, for example, the contribution of high quality ‘deliberate’ practice has been widely emphasized as a key contributor to performance and sport expertise (see Baker & Young, 2014 for a review). On the other hand, the extent to which other research findings can be applied to athletes with a disability is unclear. For instance, Côté and his colleagues (Côté, 1999; Côté, Baker, & Abernethy, 2007) have identified three stages that high performance athletes move through on their way to expertise; sampling, specialization and investment. While these phases may adequately describe the typical developmental trajectory in mainstream sport

athletes, it is not clear how applicable they are to athletes with a disability. For example, due to the disability severity and the time-course for when athletes obtain their disability (i.e., congenital versus acquired), not to mention the limited opportunities for participation in parasport compared to mainstream sport (Finch, 2001), the ability to ‘sample’ sports in early stages of their career may not be possible for many developing athletes with a disability.

It is important that parasport athletes are provided with appropriate sport-specific training to maximize development and performance. In order to provide context-specific models, identifying and understanding unique aspects of development within parasport is necessary. Further, sport-specific parasport training models could provide coaches and parasport athletes with clear direction on effective training practices, as well as highlight the potential barriers that may limit the development of athletes with a disability across all competition levels. With these outcomes in mind, the purpose of this systematic review was to synthesize the available studies that have explored aspects of development (i.e., developmental trajectories, training histories) of athletes with a disability and examined the key determinants of successful development and sporting performance.

Method

Literature Search

Using the Preferred Reporting Items for Systematic Reviews and Meta- Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009), a search was conducted for relevant articles from 1950 to September 1, 2015 using a widely used general database (Web of Science) and a sport-specific database (SportDiscus). PRISMA is commonly used as an evidence-based minimum set of items when conducting systematic reviews (Moher et al., 2009). Key search terms were grouped into two conceptual categories: (1) the targeted athletes (para

athletes, paraplegia, paraplegic, tetraplegic, plegic, plegia, disabled athletes, athletes with disability, Paralympics, elite wheelchair and wheelchair athletes) and (2) athlete development (expertise, expert, deliberate practice, early specialization, specialization, performance, high performance, high performance athletes, elite performance, skill acquisition, practice, athlete development, maturation, divergent thinking, visual motor, motor learning, perceptual expertise and talent identification). Key terms were considered individually and with two terms together (i.e., para athletes AND high performance athletes). A pilot search resulted in exclusion of the key terms “disability” and “para” due to the overwhelming quantity of results that were unrelated to the focus of this review. In addition to the database search, reference lists of all resulting articles were scanned for any additional articles.

Inclusion Criteria

This review focused on aspects of development in athletes with a disability. Studies were included if they contained each of the following components: a) *Skilled Participants*: Only studies that included athletes in the category of skilled, talented, or experts were included in this review. For example, studies involving sport or physical activity in rehabilitation or general participation were not included. Therefore, if studies failed to mention the competition level of the athletes and/or athletes competed at a level lower than national level, the studies were excluded (i.e., high school, university or recreational physical activity participants). The purpose of this stipulation was so the focus remains on ‘skilled’ individuals to help understand and monitor the path to excellence. b) *Time-Based Comparison*: The study must have considered a performance-related variable over a period of time that would allow change to occur. Therefore, studies must contain a time element (i.e., retrospective or prospective) in assessing developmental variables.

Other inclusion requirements for the studies were that articles had to be written in English, peer reviewed and published after 1950. Articles based on (a) wheelchair/prosthesis, (b) policies, rules or laws of the game, (c) societal views and media coverage, (d) patient rehabilitation, (e) learning and mental disabilities, and (f) boosting and doping articles were excluded from collection as they were considered outside the scope of this review. The remaining articles consisted of high performance samples focused on kinematics, biomechanics, performance tests and physiological responses, or athletes' responses to competition and training.

Quality Assessment

Quality assessment of the papers was performed using Version 11 of the Mixed Methods Appraisal Tool (MMAT; Pluye et al., 2011). The MMAT assesses the methodological quality of the papers using a nominal scale (“yes,” “no,” and “can’t tell”) with scores varying from 25% (one criterion met) to 100% (all criteria met). The MMAT was designed to appraise the quality of five types of articles (qualitative, non-randomized quantitative, mixed methods, randomized controlled trials, and quantitative descriptive studies) using 19 methodological criteria (Pluye et al., 2011). The inter-rater reliability of the MMAT has been established (Souto et al., 2015). Two reviewers assessed the quality of the articles independently for inter-reliability and scores were compared.

Results

Study Selection

Figure 1 depicts the different phases of data retrieval through a PRISMA table. All 21 articles scored 100% on the MMAT assessment by both raters.

Design and Sample Characteristics

The majority of the studies included in our review were published after 2001 (15/21). Twenty studies used a quantitative non-randomized study design, including non-randomized controlled trials, cohort studies, or cross-sectional analytic studies. West, Taylor, Campbell, and Romer (2014) used a randomized placebo-controlled design. Study samples ranged from 6 to 125 participants. Three studies did not mention the sex of the participants (i.e., Bednarczuk, Rutkowska, & Skowronski, 2013; Huonker, Schmid, Schmidt-Trucksäb, Grathwohl, & Keul, 2003; Verges, Flore, Nantermoz, Lafaix, & Wuyam, 2009), while the other 18 studies examined predominantly male samples (83%; 413/498). Six studies examined participants across multiple sports, while wheelchair basketball had the most sport-specific studies (n=5). Only four studies used a control group for outcome comparisons; two of the studies had a placebo while the other two held a testing variable constant in the control group. Five other studies used comparison groups that included healthy non-athletes with impairments, mainstream sport athletes, and non-athletes without impairments. Athletes with a wide range of impairments were included in the studies; amputation, post-polio, paraplegia and spina bifida appeared in multiple studies, but spinal cord injury was the most common impairment classification (See Table 1 for full study descriptions and Table 2 for the full list of sports and disabilities).

Thematic Areas

The authors examined the 21 articles and extracted themes independently; after discussion, three conceptual categories emerged. The first included studies that focused on *training and practice* (n=9), second was *short-term interventions* (n=8) and last, *long-term changes due to training* (n=4). Analysis of the studies in each conceptualized category generated a common theme across studies within each category. The studies' findings and the common theme of each category are discussed below.

Training and practice

The studies captured under this category observed and evaluated training characteristics of athletes with a disability. A total of nine studies looked at training and practice routines of high performance wheelchair athletes. Five studies explored characteristics of training; two examined multiple sports (Liow & Hopkins, 1996; Watanabe, Cooper, Vosse, Baldini, & Robertson, 1992) and the other three focused on swimming (Fulton, Pyne, Hopkins, & Burkett, 2010), wheelchair track (Davis, Ferrara, & Nelson, 1993) and road racing (Hedrick, Morse, & Figoni, 1988). Of the nine studies, seven used questionnaires to collect their data, while another study used a questionnaire and implemented an experiment using a computer controlled wheelchair ergometer (Van der Woude, Bakker, Elkhuisen, Veeger, & Gwinnal, 1998). Last, Bednarczuk and colleagues (2013) examined training intensity of road racers by measuring energy costs and collecting training logs of athletes with a disability.

The five studies focusing on training regimens indicated that training programs were divided into four phases (i.e., preparation/build up, pre-competition/overload, competition/taper and post-competition/active rest) based on competition dates. All five studies explored the implementation of the four phases of training and observed the quality of training and variability between athletes with a disability (Davis et al., 1993; Fulton et al., 2010; Hedrick et al., 1988; Liow & Hopkins, 1996; Watanabe et al., 1992). All the participants reported devoting practice time to aerobic training but involvement in other forms of practice varied between athletes with a disability. Davis and colleagues (1993) emphasized the lack of coaches for athletes with a disability training for the 1988 Paralympics (53% had no coach). They also found that aerobic training of athletes with a disability training without a coach was similar to those competing recreationally (Davis et al., 1993).

Ferrara and colleagues (Ferrara, Buckley, Messner, & Benedict, 1992) recommended the development of conditioning programs that emphasize both the aerobic and anaerobic energy systems to reduce number of injuries in competitive skiers. Van der Woude and colleagues (1998) measured propulsion technique and anaerobic performance of athletes with a disability, with findings demonstrating performance was strongly associated with training hours and wheelchair functionality. Bednarczuk and colleagues' (2013) main finding demonstrated high variability between training of athletes with a disability preparing for the same competition. Last, Fay and colleagues (Fay, Breslin, Czyz, & Pizlo, 2013) found a positive correlation between shooting accuracy, years of experience and accumulated hours of practice.

The role of the coach in training athletes with a disability. A recurring theme in this sub-category was the role of the coach and their contribution in training. Paraspport athletes without a coach lacked feedback and were inconsistent in their training (Hedrick et al., 1988). Further, a lack of structure in training resulted in overtraining and ineffective results (Liow & Hopkins, 1996; Watanabe et al., 1992) and increased probability of injuries (Ferrara et al., 1992). In addition, paraspport athletes without coaches won fewer medals in the 1988 Paralympics compared to athletes with a disability training with coaches (Davis et al., 1993). Fulton and colleagues (Fulton et al., 2010) noted improvements in coaching and training of high performance swimmers but concluded that coaches should be more aware of different impairments and athlete differences when prescribing training cycles. While the aforementioned studies examined training of athletes with a disability, the focus was on the coaches' role and the influence of current training on performance rather than training that led to expertise.

Short-term interventions

The focus of the studies in this category was on the implementation of different forms of training to immediately increase physiological output in order to enhance performance. Six out of eight articles focused on sport-specific training, with the majority consisting of wheelchair basketball (n=4) and wheelchair rugby athletes (n=2). From the eight articles, seven implemented a short-term intervention to evaluate the physiological responses to training, with one intervention lasting four weeks, another for eight weeks and majority for six weeks (n=5). Last, Roy and colleagues measured heart rate of wheelchair tennis athletes using an arm crank ergometer (Roy, Menear, Schmid, Hunter, & Malone, 2006). Five of the seven studies had a control/comparison group; one study used a control group that received no treatment (Ozmen, Yuktasir, Yildirim, & Yalcin, 2014), two other studies contained placebo groups as their controls (Goosey-Tolfrey, Foden, Perret, & Degens, 2010; West et al., 2014), and one study compared healthy, students without impairments to the wheelchair athletes (Turbanski & Schmidtbleicher, 2010).

The most common training intervention was strength training (n=3), where two studies attempted to increase sprint and agility; one in wheelchair basketball (Ozmen et al., 2014) and one in sledge hockey players (Sandbakk, Hansen, Ettema, & Rønnestad, 2014). Athletes with a disability in both groups demonstrated improvements in speed and agility. The other study looked to enhance strength and power of wheelchair basketball and wheelchair rugby players (Turbanski & Schmidtbleicher, 2010). Athletes with a disability displayed improvements in strength and power as well as enhanced intermuscular and intramuscular coordination. Oudejans and colleagues (2012) study implemented a visual control training to enhance shooting performance of wheelchair basketball players. Players that received the visual control training performed better in the post-test shooting test.

Two of the studies implemented inspiratory muscle training (IMT) to increase aerobic performance in wheelchair rugby (West et al., 2014) and wheelchair basketball players (Goosey-Tolfrey et al., 2010). Wheelchair rugby players from West and colleagues' (2014) study displayed improvements in aerobic performance tests with increased peak oxygen uptake, peak work rate and peak exercise rates. The experimental group from Goosey-Tolfrey and colleagues' (2010) study that received high intensity IMT showed improvements in respiratory function. But similarly, the control group, which received a very low intensity IMT, displayed similar outcomes as to the experimental group. Therefore, the authors concluded that minimal-intensity IMT is sufficient to improve respiratory function and quality of life. Another study (Verges et al., 2009) examined aerobic performance using respiratory muscle training (RMET) program with endurance parasport athletes. The training resulted in increased respiratory muscle function and slightly modified performance but no significant improvement in inspiratory endurance strength and power output. Roy and colleagues (2006) emphasized the importance of aerobic training and recommended highly trained wheelchair tennis players replicate the intensity of matches in training to habituate their cardiovascular system to competition stress levels.

Success of short-term training interventions. The success of the interventions was the dominant theme of this sub-category. The parasport athletes in training and conditioning programs displayed improvements in the targeted performance scores albeit through various training objectives. Strength training programs improved speed, agility, strength and power (Ozmen et al., 2014; Sandbakk et al., 2014; Turbanski & Schmidtbleicher, 2010). IMT enhanced aerobic performance and respiratory functions (Goosey-Tolfrey et al., 2010; West et al., 2014). Verges and colleagues (2009) increased respiratory muscle function implementing the RMET. Last, Oudejans and colleagues (2012) enhanced parasport athletes' shooting performance by

implementing visual control training. Surprisingly, the training history of athletes with a disability was not the foci of any of the studies. Although athletes with a disability may be able to translate some of the findings to existing training in order to improve performance, there were no specific guidelines on how non-elite parasport athletes could implement short-term interventions to enhance performance to advance in their sporting career.

Long-term changes due to training

Studies in this sub-category examined the physiological adaptations that occur due to long-term training and its influence on physical performance. Four articles examined the influence of long-term training in high performance wheelchair athletes. Two of the four studies had wheelchair basketball athletes as participants. Di Russo and colleagues (2010) examined the components of executive functioning between athletes with a disability from open-skill sport (wheelchair basketball), closed-skill sport (swimming) and non-athletes without impairments. Ternovoy and colleagues (Ternovoy, Romanchuk, Sorokin, & Pankova, 2012) observed cardio-respiratory system and autonomic functions of four groups; wheelchair basketball athletes, active non-athletes with impairments, active non-athletes without impairments and football players without impairments. Huonker and colleagues (2003) examined a similar outcome with tennis players, road cyclists and non-athletes, all of whom did not have impairments. Last, Lovell and colleagues (Lovell, Shields, Beck, Cuneo, & McLellan, 2012) examined the aerobic capabilities of hand cyclists with spinal cord injury (SCI) with age-matched physically active SCI non-athletes.

Di Russo and colleagues (2010) suggested that athletes with a disability in open-skill parasports (i.e., actions may vary in an unpredictable environment) compensate for the delayed executive processing. Wheelchair basketball athletes (open-skill) performed better on reaction

time tasks, response inhibition tasks and execution processing tasks in comparison to swimmers (closed-skill; predictable environment and responses can be planned). Ternovoy and colleagues (2012) assumed changes in autonomic regulation shown in motor activity and performance in respiratory tests were due to the extensive training. Huonker and colleagues' (2003) findings suggest that the athletes with impairments' peripheral arteries adapt to the physiological demands as the volumetric blood flow had increased compared to their respective control groups. Lovell and colleagues (2012) found higher VO_2 peak, peak heart rate and peak power for the high performance athletes with a disability compared to age-matched control group.

Adaptation of body functions due to long-term exercise. Overall, from the limited available literature, there appears to be adaptation by certain physiological body functions due to continuous long-term training. Athletes with a disability with extensive training displayed higher respiratory volume (Huonker et al., 2003; Ternovoy et al., 2012) and performed better on respiratory tests (Lovell et al., 2012; Ternovoy et al., 2012). Training in open-skill parasports (e.g., wheelchair basketball) also appeared to provide improvements in executive functioning and event-related potentials (e.g., response inhibition, attention switching). The findings demonstrate the benefits of long-term training; however, there is lack of insight on the appropriate training modifications necessary to reach the expert level.

Discussion

The purpose of this systematic literature review was to identify available studies that have explored aspects of development in athletes with disabilities. The focus was on studies that examined skilled participants (i.e., international or national level athletes) and contained a time-based comparison that tracked performance-related variables. The articles identified in our search suggest research into the developmental trajectories of athletes with a disability is

currently a small literature but is steadily growing. Based on the findings of our review and MMAT scores, the methodological quality of the studies is strong. However, the diversity of the topic areas (magnitude of disabilities, classifications, number of sports) suggests additional, carefully constructed research is needed before making firm conclusions about the nuances of parasport athlete development.

For instance, there was a disproportionate focus on short-term interventions and training programs to enhance performance in practice and competition. Although results demonstrated improvements in performance of athletes with a disability and results appear insightful for trainers and coaches, none of the studies have been replicated. In addition, no follow-up has been implemented to assess the sustainability of improvements. Further, relative to the range of Paralympic sports the number of sports examined empirically was small.

The lack of resources continues to be a theme mentioned in the literature reviewed. Parasport athletes repeatedly mentioned lack of training regimen and programs tailored to their respective parasports (i.e., Liow & Hopkins, 1996). The lack of training programs may have contributed to the variability in parasport athletes' training (i.e., Watanabe et al., 1992). The availability of resources appears to be a problem for coaches as well. Many athletes mentioned training without a coach and even when a coach was present, coaches' knowledge did not meet the standards of the competition athletes were training for (i.e., Davis et al., 1993). Coaches failed to take into consideration disability factors such as difference in abilities between athletes, physical barriers and required preparations prior to training and competition (i.e., Fulton et al., 2010). Coaches' lack of knowledge resulted in a substandard quality of training that failed to maximize athletes' potential in training and competition. Clearly, coaches' knowledge of the parasport is important to provide quality training and prepare athletes for competition, but when

the coach lacks adequate knowledge of the unique difficulties athletes face due to their disability, it is difficult to formulate an effective training environment, regardless of the quality of their knowledge about the parasport.

In addition to short-term interventions, studies that explored long-term consequences of practice and training provided some insight on benefits of training. Due to limited literature available, researchers have taken an explorative approach, and none of the current studies have provided information regarding how to maintain long-term training or the most effective ways to train. Rather, findings described approaches to training and highlight that training does have physiological benefits that contribute to performance. Interestingly, there appears to be an overarching link between the processes (e.g., having a coach) and mechanisms (e.g., executive functioning) of performance. For example, coaches' presence in training appears to decrease variability and inconsistencies of parasport athletes' training. Parasport athletes who trained with a coach achieved better results in competitions compared to parasport athletes training without a coach. Similarly, there are physiological benefits (i.e., executive functioning, aerobic conditioning) from long-term training which translate to better performance. The majority of the processes identified in this review related to the concept of training. Whether it was presence of the coach that reduced training variability or improvements from long-term training, it appears that the quality and quantity of training results in benefits that translate to mechanisms of performance. The need to provide sport-specific and/or general recommendations on effective ways to train to maximize return still exists.

A goal of this review was to inform the development of effective training programs and developmental trajectories for athletes with a disability. Unfortunately, the majority of the studies in this review emphasized the lack of training programs and sport specific guidelines for

athletes with disabilities. Researchers explored training characteristics and physical performance of parasport athletes, but only a couple provided recommendations to shift focus of training to increase performance and maximize talent (i.e., Oudejans et al., 2012). Furthermore, the lack of research on development of athletes with a disability in parasport highlights the value of future work examining sport-specific analysis and developmental trajectories of successful parasport athletes. Understanding successful development of athletes with a disability, and creating sport-specific training guidelines, will assist coaches in designing training sessions for parasport athletes at all levels of competition and ages. Perhaps more importantly, it will provide the developing parasport athletes with clearer direction, providing a more thorough understanding of the pathway to becoming an elite parasport athlete.

Limitations of this Review and Direction for Future Studies

While this review provides an important ‘state of the science’ review of research on parasport athlete development, there are some notable limitations. First, with respect to assessment of the research results, training information (i.e., training hours, type of training) was reported in different units (i.e., minutes, hours, weekly, monthly) and as a result, it was not possible to evaluate similarities or differences between training characteristics of various parasport athletes from different sports/studies. In addition, the existing body of literature focused heavily on male athletes, making generalizations of the overarching findings from this review to females difficult. Further, our review was limited to studies published in English which would have excluded any research published in non-English language journals.

With regards to additional work in this area, the areas of weakness in the current review suggest that future work should look to increase sport-specific examinations, target both sexes and explore variables specific to development that contribute to enhancing long-term skill

acquisition and superior performance. The limited number of female participants in the reviewed studies reflects the disparity between the parasport athletes competing at the Games. For example, the 2008 Beijing Games attracted 1,383 female athletes compared to 2,568 male athletes and the 2012 London Games illustrated an increase in both groups' participation (1,501 female and 2,736 male athletes). Interestingly, the Rio 2016 Games are predicted to attract approximately 1,650 female athletes which is a 9.9 per cent increase on London 2012 Games and more than double of the 1996 Atlanta Games (790 female participants) ("Rio 2016," n.d.). Therefore, moving forward, it is paramount that researchers focus on sex differences in parasport athletes' development and determining variation in training opportunities between the two groups.

In order to create appropriate sport-specific training programs and strategies, we have to increase our understanding of the nuances of development in parasport athletes (e.g., demographic backgrounds, age of attainment of motor and sport milestones, etc). In addition, understanding the impact of high quality 'deliberate' practice (Baker & Young, 2014) and the role of sampling and specialization (Côté, 1999; Côté et al., 2007) on parasport athletes' development could be especially important for tailoring training programs to different phases of development. Importantly, understanding the effects of disability (congenital/acquired, forms of disability) will be critical for developing evidence-based models of development for athletes with a disability.

Overall, the existing literature on parasport athletes' developmental trajectories is steadily growing but additional studies providing sport-specific training and insight are essential to provide athletes with a disability and coaches at all levels the best opportunities to maximize development and increase sporting success.

Chapter Three:
The Influence of Disability on Training and Development of Canadian Wheelchair
Basketball Players

This manuscript has been submitted for review to European Journal of Sport Science and is presented in its submitted form. All references for this manuscript are presented in Chapter 5.

Summary

Considering the growth in research examining the development of mainstream sport athletes over the past two decades, studies of parasport athletes' development have been surprisingly limited. While similarities in developmental trajectories between mainstream sport athletes and athletes with disabilities may exist regarding factors such as the value of practice, which tend to be universal regardless of context, disability-related issues (e.g., whether the disability was congenital or acquired) may influence the course of development, affecting variables such as starting age, participation in other sports and developmental milestones. Fifty-two male and female athletes training with the Wheelchair Basketball Canada National Academy provided detailed training histories. Athletes illustrated similar developmental patterns (e.g., milestones, training adjustments) as they progressed through their sporting career. However, athletes with congenital disabilities started wheelchair basketball and unorganized practice at a significantly younger age ($t(49) = -4.35, p < .001, d = 1.32, t(49) = -3.49, p < .001, d = 1.03$, respectively). While athletes with congenital disabilities continued to reach the majority of the sporting milestones at a younger age, athletes with acquired disabilities were able to reach the key milestones (e.g., national debuts) at a similar age. Athletes' disability severity did not influence the projection of development nor the time invested to training. Future work may consider examining developmental trajectories and training histories of athletes in various parasports to contribute to the limited literature and extend our understanding of athletes' development and skill acquisition.

Introduction

Melvin Juette, also known as the ‘wheelchair warrior’ won two gold medals and two bronze medals in international competitions from 1994 to 2000 competing with the United States’ wheelchair basketball team. Recollecting on the incident, Melvin realized becoming paralyzed was “both the worst and best thing that happened to him” (Berger, 2008, p. 313). On April 6, 1986, in a gang related incident, Melvin suffered paralysis from a gunshot to his lower back (Berger, 2008). As part of his rehabilitation, Melvin joined a wheelchair basketball team which helped him adopt a new athletic identity, while the sporting experiences and interaction with teammates increased his confidence and contributed to developing a sense of belongingness (Berger, 2008). Although the type of disability (i.e., whether the disability is congenital or acquired) and circumstances that lead to sustaining an injury may differ, the majority of athletes report experiencing the feeling of competence and a sense of accomplishment (Banack, Sabiston, & Bloom, 2011), creation of identity and recognition as an athlete (Fung, 1992; Pensgaard, Roberts, & Ursin, 1999) and feeling of being in control and autonomous (Wheeler, et al., 1999) as a result of sport participation and competition.

Further, the elite athlete status provides athletes with the master identity that increases confidence, mental strength, personal empowerment, and improved health and fitness (Huang & Brittain, 2006). As evident from the research, participation in parasport contributes to a better quality of life and psychosocial well being; therefore, it is paramount to provide guidelines regarding successful development and training-related recommendations to emerging parasport athletes. However, literature examining parasport athletes’ developmental trajectories and training histories is scarce (Dehghansai, Lemez, Wattie, & Baker, in review). Moreover,

differences among athletes with acquired and congenital disability regarding their progress through sporting career is relatively unknown.

In contrast, in recent decades, there has been increasing interest in the developmental trajectories that facilitate mainstream sport athletes' progression to the highest level of competition (e.g., Baker & Wattie, *in press*). The complexity of variables that dynamically interact across development to influence this progression has made it difficult for researchers and practitioners interested in understanding the pathway(s) to sport expertise. This complexity is further complicated when discussing athletes in parasport contexts, who have additional constraints unique to the specific structures of their sport and the limitations of their disability.

In many respects it is likely that some of the issues affecting the development of athletes with disabilities are similar to those affecting mainstream sport athlete populations, such as the need for relevant sport-specific training programs to enhance skill acquisition. Over the past two decades, researchers have explored several areas that might be relevant to parasport athletes' development, including the influence of various forms of practice (e.g., Helsen, Starkes, & Hodges, 1998), the various processes of skill acquisition (e.g., Baker & Young, 2014), differences between early specialization and diversification (e.g., Baker, Cobley, & Fraser-Thomas, 2009) and the need for long-term athlete development models (see Côté's 1999 Developmental Model of Sport Participation or Australia's Foundations, Talent, Elite and Mastery Model from Gulbin, Croser, Morley, & Weissensteiner, 2013). It is important, however, to note that while there may be some similarities between developmental constraints in para- and mainstream sport athlete populations, disability-related variables introduce additional complexity that undoubtedly influence the developmental trajectories of parasport athletes. For example, mainstream literature has shown a positive correlation between accumulated hours of deliberate

practice and athletes' skill level (Baker & Young, 2014). Arguably, given the variability of injury onset, athletes with congenital disabilities may have the opportunity to train and participate in parasports at an earlier age than athletes with acquired disabilities. While mainstream literature has demonstrated the contribution of deliberate practice on successful performance (e.g., Baker, 2003), it is unknown whether the athletes with congenital disabilities have an advantage for being exposed to this type of domain-specific training earlier and whether athletes with acquired disabilities lead a different path to expertise due to the variability in their training.

On the other hand, Baker, Côté and Abernethy (2003) found a significant negative correlation between the number of additional activities mainstream sport athletes participated in and the hours athletes invested in sport-specific training in order to reach expert level. Athletes with acquired disabilities may be able to transfer general cognitive skills (i.e., pattern recognition) acquired in mainstream sports and at the same time, the preceding experiences may assist in skill acquisition and adapting to the demands of parasport. However, to date, parasport athletes' experience prior to sustaining an injury has not been examined (Bednarczuk, Rutkowska, & Skowronski, 2013) and it is uncertain whether athletes with a disability are able to transfer general cognitive skills between sports similar to those reported by mainstream sport athletes (Abernethy, Baker, & Côté, 2005).

Therefore, examining developmental differences between athletes with congenital and acquired disabilities will provide insight on differences between these groups and contribute to our understanding of how each group negotiates aspects of developmental progress to expertise. In order to develop training programs tailored to meet the needs of athletes with disabilities (Bednarczuk et al., 2013), a more complete understanding of the unique developmental and

performance factors associated with athletes' disabilities (e.g., acquired vs. congenital) is necessary. Another disability-related issue associated with performance and development is disability severity. Existing literature has examined the influence of athletes' disability severity by comparing their performances to their respective sporting disability classifications (e.g., Vanlandewijck et al., 2004). Although classifications differ between sports, athletes' classification has been measured based on their physical abilities and prowess to perform certain general sporting tasks, and findings indicated significant differences on performance (e.g., Brasile & Hedrick, 1996; Malone, Gervais, & Steadward, 2002). However, the influence of the disability severity on athletes' development has not been examined. It is unknown whether athletes with more severe disabilities train similar hours and progress similarly in their development compared to athletes with less severe disabilities (i.e., higher classification).

To this end, the primary objective of this study was to obtain a better understanding of development in Canadian Wheelchair Basketball players with respect to their disability type and severity of their disability. Due to the lack of existing literature on parasport athletes' development, an exploratory approach was taken to obtain both descriptive and inferential knowledge; however, a hypothesis was generated based on existing mainstream sport and parasport literature. Hedrick and colleagues (Hedrick, Morse, & Figoni, 1988) noted parasport athletes did not significantly differ in their training regimen while controlling for the severity of athletes' disability. Therefore, we hypothesized athletes' disability classification (i.e., severity of disability) would not influence the progress of development and therefore athletes will reach milestones at a similar age regardless of the severity of their disability. In addition, an exploratory approach was taken to obtain a better understanding of athletes' disability type (i.e., congenital or acquired) and its influence on athletes' development. However, without any

previous work to support our prediction, we only assume that there might be more variability between athletes with acquired disabilities and the manner in which they progress through their development to expertise relative to athletes with congenital disabilities. In addition, the interaction of athletes' sex and competition level, accompanied with disability factors, will be examined to obtain a more in-depth understanding of this neglected cohort.

Method

Participants

Fifty-two male and female athletes training with the Wheelchair Basketball Canada National Academy in Toronto, Canada completed and returned a modified version of the Developmental History of Athletes Questionnaire (DHAQ; Hopwood, 2013). All participants provided informed consent to involvement in this study and the project received approval from our university's institutional ethics review board. Participants were categorized based on their competition level (i.e., provincial, national, and international) into junior, senior and precocious levels of competition. Athletes who compete at *both junior and senior competitions* were labeled as 'precocious' for demonstrating greater abilities at a young age (i.e., the ability to play at a senior level while still at junior ages).

Instrument

All participants completed a modified version of the Developmental History of Athletes Questionnaire (DHAQ; Hopwood, 2013), a validated athlete history survey that examines several areas of athlete development including demographic and career information, developmental milestones, practice history, participation in other organized sports, and disability (including: injury classification, source of injury, etc.). Minor modifications were made to the questionnaire

in order to make the instrument more specific to this population (e.g., “first participation in wheelchair basketball” instead of “first participation in your primary sport”).

DHAQ sections. The career information section collected information regarding athletes’ wheelchair basketball career (e.g., highest level of competition reached, current competition level). Sporting milestones examined participants’ ages at which they reached various milestones specific to their training and developmental experiences. For example, athletes were asked to report the age they started wheelchair basketball and various forms of practice. In addition, athletes were asked to report the age which the idea of becoming an elite athlete emerged. Milestones prior to athletes’ decision to become elite (i.e., debuts and advancements in sporting career) as well as subsequent events (i.e., training modifications) provides a general outlook on athletes’ transition from sampling to specializing years. Research in career development has shown career growth is positively related to work promotion and progression of career goals (Weng & McElroy, 2010). Therefore, debuts and becoming regular players at national and international level of competitions were identified as key milestones that may have affected athletes’ motivation to remain in sport, commit to further training and progress through the next stages of sporting career.

Participants also provided information on different forms of practice (e.g., hours devoted initially, current training hours). Practice history data were collected under two categories; ‘unorganized involvement’ and ‘deliberate practice.’ Unorganized involvement was defined as activities that focused on *enjoyment*, but rules of the game were adapted from the standardized sport rules. In contrast, deliberate practice was based on Ericsson and colleagues’ (Ericsson, Krampe, & Tesch-Römer, 1993) study on role of deliberate practice on acquisition of expert performance. Deliberate practice was defined in the questionnaire as “practice activities done

with the specific goal of improving performance, and which; are performed in a *daily, work-life manner*, require *effort* and *attention*, and do *not* lead to immediate *social*, or *financial rewards* and are frequently *not* enjoyable to perform.”

Further, athletes were asked to report the number of other organized sports participated in. Last, the disability section of the questionnaire consisted of questions such as ‘type of disability’, ‘sport disability classification’, ‘congenital vs. acquired’, and if acquired, ‘cause of disability’, “age incident occurred” and ‘sports played prior to injury.’ Athletes are classified based on their trunk movement during execution of basketball skills such as pushing and handling the wheelchair, shooting, rebounding, passing and dribbling the ball. The higher the athlete’s classification (i.e., to a maximum of 4.5), the more trunk movement the athlete has (see International Wheelchair Basketball Federation (2002) for more information on wheelchair basketball classification system). Therefore, athletes’ sport classification was used as determinant for the severity of their disability.

Statistical Analyses

Pre-analysis procedures. Assumptions of normality and multicollinearity were examined prior to the inferential analyses. Skewness and Kurtosis for all inferential tests were within normal parameters (West, Finch, & Curran, 1995).

Milestones. T-tests and ANOVAs were performed to measure differences between groups regarding the age at which athletes reached each milestone. The independent variables (IVs) in this study were athletes’ disability type (congenital or acquired) and the severity of disability (disability classification) (see Figure 1 for list of milestones).

Statistical analyses. Dependent variables that passed the aforementioned screening were evaluated in a general linear model (GLM). The purpose of implementing a GLM was to

determine contribution of each IV on dependent variables while holding the other IV constant. In addition, GLM's overall model provided an understanding of the IVs' collective contribution to the milestones and the variability of the milestone that can be explained by IVs collectively. Disability type was implemented as a fixed factor while severity of disability was included as a covariate. Subsequently, a secondary GLM was implemented with the addition of competition level and sex as fixed factors to examine interaction of disability factors with athletes' sex and competition level. Athletes competing at provincial level were excluded due to the limited number of participants for this analysis reducing the sample size to thirty-nine participants. Therefore, the sub-groups in competition level consisted of 'national' (n=13) and 'international' players (n=26). Models with significant outcomes were compiled for a final multivariate analysis of variance to assess the contribution of each IV on each milestone while holding other significant milestones and IVs constant. Further assessments included observing the variability that can be explained by the combination of the targeted IVs.

Training history. ANOVAs, t-tests, and GLM procedures were implemented using the aforementioned IVs to examine group differences regarding athletes' training history. Training variables included in the analyses were 'hours devoted to unorganized practice beginning of career', 'hours currently devoted to unorganized practice', 'hours devoted to deliberate practice beginning of career' and 'hours currently devoted to deliberate practice'.

Precocity. ANOVAs were implemented using athletes' competition status (junior, senior or precocity) as an independent factor to examine differences amongst groups in the age they reached the milestones. Further, ANOVAs were implemented to examine differences between groups regarding the hours devoted to various forms of practice.

All statistical analyses were performed using SPSS Version 22 (IMB Corp, 2013). Data were evaluated at the $p \leq .05$ level of significance with partial eta squared as the effect size measure and Fisher's least significant difference (LSD) as post hoc comparison for significant main effects.

Results

Demographics

Sex. Males made up the majority of participants ($n=37$, 71.2%) with ages ranging from 14.77 to 38.07 years ($M=22.13$; $SD=6.64$) at the time of questionnaire completion. Female participants had a mean age of 25.24 ($SD=7.93$) years with ages ranging from 17.21 to 40.26 years. Six males and one female competed at the provincial level, 11 males and two females at the national level and 16 males and 10 females at the international level.

Competition level. Seventeen athletes competed at the junior level and had an average age of 17.75 ($SD=2.16$) years, 35 athletes competed at the senior level with an average age of 29.59 ($SD=6.35$) years and the fourteen precocious athletes had an average age of 19.27 ($SD=2.81$). Six junior athletes and one precocious athlete competed at the provincial level with the average age of 17.23 ($SD=1.43$) years. Seven junior athletes, five precocious athletes and one senior athlete competed at the national level with the average age of 18.32 ($SD=3.39$) years and one junior athlete, six precocious athletes and 25 senior athletes competed at the international level of competition with the average age of 27.24 ($SD=7.14$) years.

Disability type. Twenty participants were born with their disability (congenital group) and had an average age of 19.81 ($SD=4.62$) years. The remaining 32 participants acquired their injury post-birth (acquired group) and had an average age of 24.96 ($SD=7.68$) years. The age athletes in the acquired group obtained their injury ranged from two to 28 years ($M=13.56$;

$SD=5.62$). The average age the injury occurred for junior athletes was 11.40 ($SD=2.07$) years, 14.18 ($SD=6.51$) years for senior athletes and 13.60 ($SD=4.88$) years for precocious athletes. The most common self-reported disabilities were Paraplegia ($n=10$), Cerebral Palsy ($n=8$), Spinabifida ($n=6$) and Amputee ($n=5$). The cause of disability was most commonly from an accident ($N=14$; car ($n=7$), sporting ($n=3$), injuries ($n=3$), and farm ($n=1$)) with cancer as the second most common cause of injury ($n=4$). Sport disability classifications were fairly distributed among the eight categories.

Milestones

When considering the group as a whole, athletes started participation in other organized sports at an average of 11.47 ($SD=5.40$) years of age and on average participated in 3.00 ($SD=2.02$) sports (excluding wheelchair basketball). Approximately three years later, players started participation in wheelchair basketball at an average of 14.22 ($SD=4.97$) years of age. Introduction to wheelchair basketball was immediately followed by participation in unsupervised ($M=14.71$, $SD=4.65$) and supervised practice ($M=15.69$, $SD=4.37$). Roughly a year after their introduction to wheelchair basketball, athletes made their debut at the junior national level competitions ($M=15.70$, $SD=2.83$). Within the same year, athletes began non-sport specific training ($M=15.77$, $SD=3.66$) (e.g., physical conditioning, weights, etc.) and became regular starting players in the junior national team ($M=15.97$, $SD=3.25$). Within the following months, athletes developed the idea of becoming elite athletes ($M=16.04$, $SD=4.52$) which led to withdrawal from other sporting activities to concentrate on wheelchair basketball ($M=17.00$, $SD=5.13$). During the same time-frame, athletes developed a relationship with their coaches ($M=17.05$, $SD=4.96$) and made a conscious decision to become an elite athlete ($M=17.26$,

$SD=4.17$) which coincided with debuts at *both* the national level competition as a senior player ($M=17.30$, $SD=3.84$) and the junior international team ($M=17.33$, $SD=2.51$).

Around the same time, athletes committed to year-round training ($M=17.49$, $SD=4.49$) and devoted all leisure time to wheelchair basketball ($M=17.62$, $SD=4.51$). Just over the age of 18, athletes became regular starting players at the junior international team ($M=18.09$, $SD=3.21$) and regular players at the national level senior competitions ($M=19.05$, $SD=4.25$). Almost a year after, athletes achieved their senior level international debut ($M=19.89$, $SD=4.59$) and roughly three years later, they became starting players on the senior international team ($M=22.9$, $SD=5.04$).

Group differences. Table 3 provides the average age athletes reached each milestone split by athletes' disability type and Table 4 presents the significant results from the two-staged GLMs process. The significance of disability factors on milestones were reduced once competition level and sex were added to the model. Analyses that revealed significant overall outcomes or explained at least 10% of variation in the outcome (i.e., $R^2 \geq .10$) were compiled for a final multivariate analysis of variance. The final model included 'first participation in wheelchair basketball', 'age started unorganized practice', 'age started deliberate practice', 'age stopped involvement in all other sports', 'age established close relationship with coaches' and 'age devoted all leisure time to wheelchair basketball' as outcome measures. Levene's test of equality of error variances demonstrated the error variance of the dependent variables was equal across all groups. The overall model was significant for 'first participation in wheelchair basketball', $F(6)=4.02$, $p < .05$, $partial \eta^2 = .67$, 'first participation in unorganized practice', $F(7)=4.35$, $p < .05$, $partial \eta^2 = .69$ and 'establishment of close relationship with coaches', $F(7)=3.18$, $p < .05$, $partial \eta^2 = .64$.

Athletes' disability type was a significant predictor in a few milestones; 'first participation in wheelchair basketball', $F(1,6)=16.29, p < .01, \text{partial } \eta^2 = .58$, 'first participation in unorganized practice', $F(1,6)=17.03, p < .01, \text{partial } \eta^2 = .59$, and 'establishment of close relationship with coaches', $F(1,6)=6.05, p < .05, \text{partial } \eta^2 = .34$. Athletes with congenital disabilities transitioned into the aforementioned milestones at a significantly younger age than athletes with acquired disabilities. Athletes' sex predicted 'first participation of deliberate practice' significantly, $F(1,7)=5.23, p < .05, \text{partial } \eta^2 = .30$ with male athletes starting participation significantly earlier. Interaction between sex and disability type was also significant in 'first participation in unorganized practice', $F(1,6)=5.06, p < .05, \text{partial } \eta^2 = .30$ which revealed female athletes with congenital disabilities starting participation in unorganized practice earlier than male athletes with congenital disabilities and the trend was reversed for athletes with acquired disabilities. The overall models' contribution to the variability of each dependent variable is listed in Table 5.

Practice History

In addition to milestones, athletes' training histories (i.e., hours devoted to various types of practice at the beginning of career and currently) were examined. Athletes devoted 3.56 ($SD=1.58$) hours per week to unorganized practice at the initial phases of their career and currently they have slightly increased to 3.80 ($SD=2.92$) hours per week. Athletes increased their deliberate training significantly, averaging 12.70 hours per week ($SD=8.75$) compared to initial phases of their career ($M=7.48, SD=6.55$), $t(66)=-4.38, p < .05, r=.47$.

A similar approach was taken to analyze differences between groups (i.e., ANOVAS and t-tests) and mean averages per disability type are listed in Table 3; however, no significant differences were identified amongst groups with respect to training history.

Precocity

ANOVAs were used to understand differences amongst the junior, senior and precocious athletes. Generally, senior athletes reached milestones at later ages than the precocious and junior athletes with some differences being significant (see Table 6 for descriptive results and average ages per group). A one-way ANOVA demonstrated significant difference between groups in the hours athletes currently devoted to deliberate practice, $F(2,44)=10.67$, $p < .01$, and post-hoc comparison using LSD test indicated senior athletes devoted significantly more hours to deliberate practice than both the junior and precocious athletes. Further, the precocious athletes devoted significantly more hours to deliberate practice compared to the junior group.

Discussion

This study explored the influence of disability factors on training and development of athletes training at the Wheelchair Basketball Canada National Academy. The majority of athletes competed at the national/international level, which enabled an assessment of developmental trajectories athletes went through on their way to elite level competition. As seen through the results, athletes in different groups (i.e., congenital or acquired) reached some milestones at different ages, however, all progressed through the milestones in a similar manner. The changes in the training performed by wheelchair basketball athletes as they progressed through their career (e.g., non-sport specific training, year-round training) were similar to those in the mainstream sport literature (see Côté, Baker & Abernethy, 2007). For instance, Canadian wheelchair basketball players increased the hours devoted to deliberate practice and as the idea of becoming elite emerged, athletes modified training regimens (i.e., year-round training) and incorporated non-sport specific trainings (i.e., weight training, conditioning). As seen in the mainstream sport literature (see Wylleman, Alfermann, & Lavallee, 2004) and from this study's

findings, evidently, it is important to continue to modify and alter training as demands of competition change as athletes transition to higher skill levels. One factor that influenced the course and timing of reaching the elite level (i.e., debuts and regular starting position at international level) was the number of hours athletes devoted to deliberate practice. These differences were evident when athletes were stratified per disability type.

Athletes with acquired disabilities reached some milestones at a later age; however key milestones (i.e., debuts nationally, regular players with national team) were reached at a similar age. Unsurprisingly, the variability amongst athletes with acquired disabilities was much higher than athletes with congenital disabilities regarding the age they reached the targeted milestones. This is likely, at least partially, the result of the variability with respect to the onset of the injury and demonstrates the difficulty in specifying a general progression to expertise regarding parasport athletes' development. One notion that has been evident in mainstream sport literature is the accumulated hours of deliberate practice and its contribution to athletes' skill level (see Baker & Young, 2014). Evidently, precocious athletes with acquired disabilities obtained their disability later than junior athletes which limited their opportunity to training; however, they devoted significantly more hours to deliberate practice and demonstrated the ability to compete with senior level athletes. Interestingly, Baker and colleagues (2003) indicated mainstream sport elite athletes accumulated more sport-specific training hours compared to the non-elites. There were no significant differences between training histories of athletes with congenital and acquired disabilities, which raises the question whether another contributing factor influenced the success of athletes with acquired disabilities in compensating for late milestones. In the same study, Baker and colleagues (2003) demonstrated a significant negative relationship between the number of other sports athletes participated in and the number of sport-specific training hours

required to reach the expert level. This may explain the ability of athletes with acquired disabilities to advance through milestones at a later age, compensate and reach key significant milestones at the same time as athletes with congenital disabilities. Athletes with acquired disabilities may be transferring skills they have acquired from mainstream sports to wheelchair basketball (Abernethy et al., 2005).

Interestingly, nearly half of the athletes in this study participated in other sports prior to specializing in wheelchair basketball. The notion of early diversification has been examined extensively in the mainstream sport literature (e.g., Baker, 2003) with concerns over negative psychological and developmental consequences of early specialization (e.g., Baker et al., 2009). Nearly half of the athletes with acquired disabilities participated in other organized sports prior to their injury and the majority competed in standing basketball. Therefore, similar to athletes from mainstream sports (e.g., Baker et al., 2009) and previous literature (e.g., Liow & Hopkins, 1996), these results suggest early specialization is not the only route to expertise in wheelchair basketball. Athletes may be using similar skill transfer to that seen in the mainstream sport literature (Abernethy et al., 2005).

Limitations and Future Direction

Although this study adds to a limited literature base regarding the development of athletes in parasport, it is not without limitations. One is the retrospective method used to obtain training and milestones data. Although the data were collected using a validated instrument, it is possible that recall bias may have affected athletes' perception of time devoted to training and the age at which milestones were attained. Future work may consider implementing a longitudinal study using training logs to better track athletes' training. Further, focusing on youth athletes would allow better observation of training methods as they progress through their

sporting career. Given the potential costs of specializing children into sports at an early age (e.g., burnout, dropouts) (Baker et al., 2009; Côté, 1999), it is important to continue to study the role of diversification in athletes' pathway to expertise. The results from this study suggest early diversification may not be a disadvantage to becoming an elite athlete. In addition, considering the complexity of disability (i.e., types of disability, severity), the variable used in this study was crude. Albeit, the findings revealed developmental differences amongst athletes with different disability types (i.e., congenital or acquired), a conceptual framework is required to operationally define and conceptualize various aspects of disability to better understand these athletes' development relative to aspects of their disability (i.e., functionality, severity, the nature of the disabilities and whether conditions are stable or dynamic). Given the limited literature regarding the development of athletes with a disability, this study highlights the constraints and complexities associated with disability-related issues in parasport athlete development.

Conclusion

This study contributes to a limited literature base regarding the development of athletes in parasports. The findings illustrate the role of diversification in early stages of athletes' career and highlight the need for continuous training modifications for successful development. Furthermore, it extends our understanding of differences between athletes with congenital and acquired disabilities' training histories and developmental trajectories.

Chapter Four: General Discussion

The growth of the Paralympics in the last half-century has been immense starting with 16 participants in the Stoke Mandeville Games to acquiring the ‘Paralympic’ title and celebrating parasport athletes’ abilities alongside the Olympians. However, the findings from the systematic review illustrated the lack of published research on athletes’ development, which facilitated the second phase of the thesis examining the influence of disability-related issues on training histories and developmental trajectories of wheelchair basketball athletes training with the Wheelchair Basketball Canada National Academy. The findings from the thesis contribute to the general athlete development literature and expand our knowledge of skill acquisition and development of parasport athletes. Further, benefits extend to translation of the results to parasport athletes from grassroots to elite levels of competition. The outcome of the thesis, theoretical and practical implications, and future research directions will be discussed below.

Summary of Thesis

The primary objective of the thesis was to examine the influence of disability-related issues on parasport athletes’ development and training history. In general, parasport athletes illustrated similar developmental patterns and training modifications as they progressed through their sporting career. Parasport athletes’ early experiences consisted of sampling multiple sports which was preceded by introduction to wheelchair basketball accompanied by unorganized practice and deliberate practice. As parasport athletes advanced in their career and the idea of becoming elite emerged, they began to modify training regimens (i.e., year-round training, increased hours committed to deliberate practice), incorporated non-sport specific trainings (i.e., weight lifting, conditioning), and eliminated involvement in other sports. However, group differences existed when parasport athletes’ disability type (whether disability was congenital or

acquired) was taken into consideration. Athletes with congenital disabilities reached the majority of the milestones (e.g., introduction to wheelchair basketball and deliberate practice) at an earlier age; however, athletes with acquired disabilities were able to reach the key milestones (e.g., debuts and regular players at national/international competition) at a similar age. Training done by athletes with acquired disabilities was assumed to have influenced their ability to accelerate through the earlier milestones. Assessment of the training histories illustrated both groups increased training hours significantly from the time they initially started training; however, there were no significant differences between the two groups. To this end, it is paramount to examine alternative factors that may have contributed to athletes with acquired disabilities' ability to close the gap as they reached the key milestones.

Implications for Theory

There is a lack of research regarding parasport athletes' development and skill acquisition. The majority of knowledge regarding athlete development comes from the mainstream sport literature. For example, Ericsson and colleagues (1993), postulate that deliberate practice contributes to skill acquisition substantially and in turn improves performance. Although their work targeted musicians, in recent years, the notion of deliberate practice has been examined in sports domain (e.g., triathlon, Hodges, Augaitis, & Crocker, 2015; field hockey, netball, and basketball, Baker, Côté, & Abernethy, 2003) and studies illustrate that elite mainstream sport athletes consistently rate higher accumulated hours of deliberate practice compared to the non-elites (Baker & Young, 2015). The parasport athletes in this study demonstrated similar trends, significantly increasing the hours devoted to deliberate practice from the initial phases of their career.

While importance of deliberate practice must be accredited, several developmental models suggest deliberate practice constitutes only a portion of the type of experiences needed for successful development. One aspect of Ericsson's theory is that total accumulated hours of deliberate practice explain differences between successful and less successful performers, and therefore, athletes must specialize in sports early to gain maximum benefit from the accumulated training hours. However, Côté's (1999) Development Model of Sport Participation (DMSP) and follow up studies (e.g., Côté, Baker & Abernethy, 2007) suggest athletes can approach sports in a different manner than specialization to build a foundation that facilitates successful development while reducing the negative psychological and developmental consequences (burnout, dropout and injuries) related to early specialization (Baker et al., 2009). According to the DMSP, the foundation of an athlete's sporting career comes from sampling multiple sports and enjoying self-directed practice (i.e., deliberate play) prior to increasing intensity and focus of training (i.e., deliberate practice) and specializing in a particular sport. Through their experiences in a variety of settings, athletes become aware of their abilities which translate to making an educated decision on the type of sport that maximizes their potential (Busseri & Rose-Krosner, 2009; Marcia, 1993).

Evidently, there are benefits to acquiring skills from multiple sports towards athletes' long-term development. For example, recent findings have illustrated athletes' ability to transfer general cognitive skills (i.e., pattern recognition) between sports (Abernethy, Baker, & Côté, 2005), and the significant negative correlation between the number of additional activities athletes participated in and the hours invested in sport-specific training required to reach the expert level (Baker, Côté, & Abernethy, 2003).

Support for the tenets of diversification was found in the training histories reported by wheelchair basketball athletes. The majority of parasport athletes in the study participated in multiple sports prior to specialization. Similar to Côté and Fraser-Thomas' (2008) recommendations in the DMSP, parasport athletes in this sample continued to modify and increase duration and intensity of training while reducing activity in other parasports as they progressed through their sporting career. The findings of this study regarding development and training of Canadian wheelchair basketball players reflects much of what is known regarding development in mainstream sport athletes. However, and more importantly, there were notable differences and this thesis contributes to a foundation for future research assessing parasport athletes' development to further extend our understanding of skill acquisition in parasport. As it stands, developmental and training guidelines for parasport athletes are limited (Bednarczuk et al., 2013), however, taken together, understanding the elements of research from mainstream sport athletes that are applicable for parasport athletes and identifying the unique constraints of parasport populations may help in creating practical guidelines for parasport athletes training from the grassroots to the international level.

Implications for Athlete Development

Based on the results from this investigation, and coupled with related work from other sports, parasport athletes in the early stages of development (i.e., competing at the grassroots level) are advised to sample multiple sports. Given the recent concerns with early specialization and the related negative psychological and developmental consequences (e.g., Baker et al., 2009), and the long-term sport-related benefits to diversification, early exposure to multiple sports appears optimal for parasport athletes' development. Parallel to the literature, the majority of the wheelchair basketball athletes pursued the diversification route to expertise. Early

diversification and ‘deliberate play’ (Côté, 1999) can facilitate the appropriate contextual environments for parasport athletes to garner general motor skills that are prerequisites to skill demands of any sport (see Côté & Erickson, 2015). Further, the breadth of experience in multiple sporting contexts may help to develop parasport athletes’ athletic identity, improve self-regulation, and allow growth of intra- and interpersonal skills (Baltes, 1997; Busseri & Rose-Krosner, 2009; Lerner, Freund, De Stefanis, & Habermas, 2001; Marcia, 1993). These traits may be critical for parasport athletes’ competitive career as coach-athlete relationship and teammate interactions become increasingly important for team selection and influence parasport athletes’ performance (Bruner, Eys, & Turnnidge, 2013; Gould, Dieffenbach, & Moffett, 2002).

Further, parasport athletes must be aware of the need for continuous training adjustments to cope with the demands of their sport as they progress through their career. Parasport athletes in this study consistently modified their training and increased the hours devoted to high intensity training. Therefore, it is suggested parasport athletes increase the hours devoted to deliberate practice, modify sport-specific trainings and continue to add non-sport specific training as they progress through their career. Further, as the decision to become elite emerges, it is recommended that parasport athletes reduce or eliminate participation in other parasports and transfer these associated resources to sport-specific training. During the more competitive stages of their career, it is paramount that parasport athletes shift their energy and time to deliberate practice, maintaining high intensity training at a consistent rate as well as focusing on sport-specific skills that require improvement.

The immediate implications highlight the importance of training in parasport athletes’ development, highlighting the significance of continuous training modifications and regulation of training intensity for optimal performance. Therefore, coaches and parasport athletes should

distinguish short- and long-term training objectives and continuously adjust the objectives as parasport athletes progress through their career.

Future Research Directions

The findings of the thesis also provide several directions for future research. Moving forward, it is important to focus on deliberate practice due to the findings of this thesis and mainstream sport literature highlighting the contribution of deliberate practice on successful performance (e.g., Baker, 2003). In this vein, future examinations should consider the influence of disability-related issues on training characteristics (i.e., how type or severity of disability may influence forms of practice, hours devoted per practice, training modifications).

Parasport athletes continuously modify training to acquire and maintain necessary skills to meet the demands of the competition. It is paramount to understand the importance of various forms of practice (e.g., skill acquisition, tactical, technical) at different stages of parasport athletes' sporting career. The micro-examination of training prioritization across parasport athletes' career span can presumably facilitate training models that contain appropriate recommendations for parasport athletes at various participation levels (e.g., differences in the training focus for grassroots versus elite parasport athletes). When dealing with athletes with acquired injuries, this can be more complicated since the onset of injury dictates the athletes' introduction to parasport. It will be important to examine differences regarding training prioritization between athletes with congenital and acquired disabilities. Moreover, the optimal quantity and intensity of training to foster skill acquisition and physical growth is also of interest. For instance, as highlighted by Ericsson and colleagues (1993), deliberate practice demands great effort and attention, which is physically and cognitively exhausting. Therefore, understanding the

appropriate ratio between deliberate training and deliberate rest necessary to avoid injuries and overtraining, and to maximize skill acquisition and development would be valuable.

Another type of training that requires further investigation, eluded to above, which appears relevant during early stages of athlete development, is deliberate play. In the DMSP, Côté and Fraser-Thomas (2008) propose that deliberate play is integral to the sampling years and facilitates creative thinking in a variety of sporting contexts. Contrary to deliberate practice, deliberate play is defined as any form of practice a) that is inherently enjoyable b) where game-rules are adapted to the skill and developmental level of the participants and c), the focus of the game is on the experience rather than the outcome. The hypothesis is that due to the lack of adult supervision, athletes participating in deliberate play indulge in unrestricted and unstructured forms of activity, which promote creative thought processing and contributes to adaptable thinking patterns. It is important to examine whether deliberate play contributes to parasport athletes' development at early stages of their career. Arguably, parasport athletes' lack of resources (e.g., facilities, transportation) (Campbell & Jones, 2002) may impede their ability to participate in unorganized sporting events (i.e., deliberate play) and in turn, limit the occurrence of such events due to the lack of participation. Therefore, attaining an understanding of the importance of deliberate play on parasport athletes' development, with the purpose of proposing policies and community-base changes to promote and facilitate access for parasport athletes to partake in such events, could be useful.

In addition, lack of resources may limit parasport athletes' opportunity to participate in multiple sports throughout their career. Given the recent discussions between the role of early diversification and specialization in successful development, examining the influence of diversification and parasport athletes' ability to transfer skills (e.g., Abernethy et al., 2005)

between parasports is ideal. More importantly, it is necessary to explore factors that may hinder parasport athletes' ability to participate in multiple parasports, ranging from difficulties in families' ability to accommodate (e.g., financially, time, transportation, etc.) to availability of parasports within the athletes' region (e.g., available leagues, teams and coaches). Despite the best of intentions in creating more sophisticated athlete development models, these personal and social factors may prove to be the most significant constraints on parasport athlete's development.

Further work should also consider the role of coaches and family members in parasport athletes' development. The role of family members within optimal environments for development of children with a disability has been extensively examined (King, King, & Rosenbaum, 2004). However, these investigations have been outside the sporting context. On the other hand, families' and coaches' contribution to athletes' successful development has been extensively noted in the mainstream sport literature (e.g., Henriksen, Stambulova, & Roessler, 2010; Wylleman, Alfermann, & Lavalley, 2004), suggesting that parents facilitate a suitable developmental environment by operating as role models during initial phases of athletes' careers and subsequently, transition to support athletes socially and financially (Bloom, 1985; Wylleman et al., 2004). Moreover, grassroots coaches with suitable developmental traits are generally supportive and encouraging while coaches in more competitive stages are demanding and critical of athletes' performance (Bloom, 1985). However, while these factors would seem intuitively appropriate to parasport athletes, their relevance is still unknown. Moreover, examining the changing needs (e.g., coaching, developmental, medical) of parasport athletes across development and linking these factors to attrition would permit assessment of factors related to dropout throughout development. In order to generate an effective developmental model

covering the nuances of parasport athletes' development, there is a need for additional research examining the influence of members directly associated with parasport athletes' sporting and home environment.

Conclusion

There is limited research on parasport athletes' development and future research is clearly required to bridge the gap between the public growth of parasport and the needs to developing athletes within the parasport system. Existing research has raised concerns over the lack of resources available in parasport athletes' sporting environments and daily lives (e.g., Campbell & Jones, 2002; Wilson & Khoo, 2013). The addition of skill development research will contribute to identifying the resources necessary for successful development and optimal training. Taken together, awareness can be raised to create new policies, advocate wheelchair-friendly infrastructures and facilities and appropriate services to facilitate an environment appropriate to development.

In conclusion, the findings of this thesis add to a limited foundation for parasport athlete development and contribute to the general topic of skill development and acquisition in sport. Through this study, a better understanding of the developmental pathways for elite wheelchair basketball players and more comprehensive understanding of the similarities and differences between athletes with acquired and congenital disabilities were established. The findings of the thesis raise awareness of the significant gaps in our understanding of parasport athlete development but provide a basic profile of important developmental milestones and the training adjustments necessary as elite parasport athletes progress through their sporting career.

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Table 1*Included Studies' Characteristics*

Author(s) & Year Published	Study Design	Main Findings	Participants (n=) (F)	Impairment	Sport(s)	Comparison Group(s)
Training & Practice						
Bednarczuk, Rutkowska, & Skowroński (2013)	Retrospective cohort study	Training regimens varied between athletes with a disability training for the same competition	13*	Visually Impaired	Distance Running	N/A
Davis, Ferrara, & Van Nelson (1993)	Retrospective cohort study	Emphasis on lack of coaches available. Aerobic training of parasport athletes without a coach was similar to those competing recreationally. In addition, parasport athletes with coaches won more medals in the 1988 Paralympics	17 (6)	N/A	Wheelchair Track	N/A
Fay, Breslin, Czyz, & Pizlo (2013)	Cross-sectional analytic study	Significant positive correlations exist between shooting percentage from various spots on the court and the years played and accumulated practice hours	12	N/A	Wheelchair Basketball	N/A
Ferrara, Buckley, Messner, & Benedict (1992)	Retrospective cohort study	Developed conditioning programs that emphasize both aerobic and anaerobic energy systems to reduce number of injuries in competitive skiers	68 (15)	Amputation SCI Spina Bifida MS Muscular Dystrophy	Sled-Skiing	N/A
Fulton, Pyne, Hopkins, & Burkett (2010)	Prospective cohort study	Existence of coaches had reduced variability in training regimens but coaches still	16 (7)	Amputation Cerebral Palsy	Swimming	N/A

		lacked awareness of personal differences with respect to athletes' impairments				
Hedrick, Morse, & Figoni (1988)	Retrospective cohort study	Athletes with a disability training without a coach lacked the necessary feedback and had inconsistencies in their training regimens	36 (10)	N/A	Wheelchair Road Racing	N/A
Liow & Hopkins (1996)	Retrospective cohort study	Lack of sport-specific training	75 (23)	N/A	Wheelchair Racing Swimming Throwing Events	N/A
Van der Woude, Bakker, Elkhuisen, Veeger, & Gwinn (1998)	Cross-sectional analytic study	Propulsion technique and performance varied among wheelchair athletes and there was a strong association between performance and functionality and training hours	67 (17)	N/A	Wheelchair Track & Field	N/A
Watanabe, Cooper, Vosse, Baldini, & Robertson (1992)	Retrospective cohort study	Lack of sport-specific training programs resulted in variability in training and debilitated performance	39 (9)	Paraplegia Quadriplegia Visually Impaired Mentally Impaired	Wheelchair Track Field Events Weight Lifting Swimming Table Tennis Archery Shooting Special Olympics	N/A
Short-Term Interventions						
Goosey-Tolfrey, Foden, Perret, & Degens (2010)	Non-randomized placebo-controlled design	IMT improved respiratory function of wheelchair basketball players	16 (8)	SCI Post Polio Spina Bifida	Wheelchair Basketball	Placebo group: Breathing technique
Oudejans, Heubers, Ruitenbeek, & Janssen (2012)	Non-randomized controlled trials	Visual control training facilitated perceptual-motor learning and enhanced shooting performance of athletes with a	10	N/A	Wheelchair Basketball	Control group: No visual training

		disability				
Ozmen, Yuktasir, Yildirim, & Yalcin (2014)	Non-randomized controlled trials	Increased sprint and agility of athletes with a disability using strength training	10	SCI Post Polio	Wheelchair Basketball	Control group: No training
Roy, Menear, Schmid, Hunter, & Malone (2006)	Cross-sectional Analytic Study	Important for wheelchair tennis players to devote more hours to aerobic training	6	SCI Amputation	Wheelchair Tennis	N/A
Sandbakk, Hansen, Ettema, & Rønnestad (2014)	Cross-sectional Analytic Study	Increased sprint and agility of sledge hockey players by using strength training	8	SCI Amputation	Sledge Hockey	N/A
Turbanski & Schmidtbleicher (2010)	Non-randomized controlled trials	Increased strength and power of wheelchair basketball and rugby players by using strength training	16	SCI	Wheelchair Basketball Wheelchair Rugby	Comparison group: Non-athletes without impairments
Verges, Flore, Nantermoz, Lafaix, & Wuyam (2009)	Cross-sectional Analytic Study	RMET increased respiratory muscle function and slightly enhanced performance of endurance athletes with a disability	9*	Paraplegia Post Polio	Nordic Wheelchair Sports	N/A
West, Taylor, Campbell, & Romer (2014)	Randomized placebo-controlled design	IMT improved aerobic performance of wheelchair rugby players	12	SCI	Wheelchair Rugby	Placebo group: Placebo inhaler
Long-Term Changes Due to Training						
Di Russo et al. (2010)	Cross-sectional analytic study	In comparison to the closed-skill sport (swimming), open-skill sport (wheelchair basketball) compensated for the delayed executive processing caused by SCI	35 (1)	SCI Amputation Poliomyelitis	Wheelchair Basketball Swimming	Comparison group: Non-athletes without impairments
Huonker, Schmid,	Cross-	Peripheral arteries adapted to	125*	Paraplegia	Cross-country	Comparison

Schmidt-Trucksass, Grathwohl, & Keul (2003)	sectional analytic study	the physiological demands as the volumetric blood flow had increased compared to the respective control groups		Amputation	Skiing Cross-country Sledding Wheelchair Basketball Wheelchair Track & Field Wheelchair Road Racing	group: Tennis players without impairments Road cyclists without impairments Non-athletes without impairments
Lovell, Shields, Beck, Cuneo, & McLellan (2012)	Cross-sectional analytic study	Wheelchair athletes scored higher on VO ₂ peak, peak heart rate and peak power test compared to the respective comparison group	20	SCI	Hand cycling	Comparison group: Healthy SCI non-athletes
Ternovoy, Romanchuk, Sorokin, & Pankova (2012)	Cross-sectional analytic study	Extensive training resulted in autonomic regulation shown in motor activity and enhanced performance in respiratory tests	51	SCF	Wheelchair Basketball	Comparison group: Mainstream sport athletes Healthy non-athletes without impairments Healthy non-athletes with impairments

Notes. (F) = Number of female participants in the study; if not indicated, no female participants in the study

*Did not mention gender of participants

SCI = Spinal Cord Injury, MS = Multiple Sclerosis, SCF = Spinal Compression Fracture

Table 2*Total Number of Appearances of Sports and Disabilities in the Included Studies*

<u>Sport</u>	<u>Number of Times Appeared</u>	<u>Impairment</u>	<u>Number of Times Appeared</u>
Wheelchair Basketball	8	SCI	9
Track & Field	6	Amputation	6
Swimming	4	Post Polio	3
Road Racing	3	Paraplegia	3
Wheelchair Rugby	2	Spina Bifida	2
Wheelchair Tennis	1	Visually Impaired	2
Sledge Hockey	1	SCF	1
Hand Cycling	1	Poliomyelitis	1
Cross-country Sledding	1	Cerebral Palsy	1
Cross-country Skiing	1	Muscular Dystrophy	1
Shooting	1	MS	1
Archery	1	Mentally Impaired	1
Table Tennis	1	Quadriplegic	1
Weight Lifting	1		

Note. SCI = Spinal Cord Injury, MS = Multiple Sclerosis, SCF = Spinal Compression Fracture

Table 3
Mean Ages per Milestone Stratified by Disability Type

	Disability Type	
	Congenital	Acquired
Milestones		
1 st participation in wheelchair basketball	10.84(3.34)**	16.22(4.72)
1 st participation in unorganized practice	12.15(3.66)**	16.35(4.51)
1 st participation in deliberate practice	14.3(2.62)^	16.56(5.02)
1 st participation: junior national competition	16.7(1.16)	17.79(3.12)
1 st non-sport specific training	14.89(2.49)	16.3(4.15)
Regular player: junior national competition	15.92(2.75)	16(3.64)
Idea of becoming elite athlete emerged	14.39(2.36)*	17.07(5.23)
Stopped activity in other sports	14.44(4.56)	18.05(4.98)
Established relationship with coaches	13.83(2.89)**	18.48(5.06)
Conscious decision to become elite athlete	15.17(2.15)**	18.61(4.61)
1 st participation: senior national competition	14.94(1.92)	16.26(3.28)
1 st participation: junior international competition	16.7(1.16)	17.79(3.12)
All leisure time devoted to wheelchair basketball	15.5(2.28)*	19.28(5.14)
Regular player: junior international competition	17.67(2.89)	18.25(3.5)
Regular player: senior national competition	16.83(2.79)^	20(4.49)
1 st participation: senior international competition	17(1)^	20.44(4.82)
Regular player: senior international competition	22.5(9.19)	23(4.54)
Practice		
Initial hours devoted to unorganized practice	4(3.08)	5.3(5.9)
Current hours devoted to unorganized practice	3.22(2.5)	3.94(3.15)
Initial hours devoted to deliberate practice	6.7(4.66)^	8(7.59)
Current hours devoted to deliberate practice	9.78(7.45)^	14.52(9.12)

Notes. * $p < .05$. ** $p < .01$. ^ $partial \eta^2 < .06$. ^^ $partial \eta^2 < .13$.

Table 4

Significant Results from Univariate Analysis of Variance (IVs=Disability Type and Disability Severity)

	Disability Type				Disability Severity			
	<i>df</i>	<i>F</i>	η	<i>p</i>	<i>df</i>	<i>F</i>	H	<i>p</i>
Milestones								
1 st participation in wheelchair basketball	1,48	18.58	.28	.00	1,37	4.69	.11	.04
1 st participation in unorganized practice	1,48	12.06	.20	.00				
1 st participation: junior national competition								
Idea of becoming elite athlete emerged	1,44	4.11	.09	.05				
Established close relationship with coaches	1,36	8.62	.19	.01	1,21	5.34	.20	.03
Conscious decision to become elite athlete	1,43	8.78	.17	.01				
1 st participation: junior international competition								
1 st year-round wheelchair basketball training	1,40	4.71	.11	.04				
Devoted leisure time to wheelchair basketball	1,29	6.33	.18	.02				
<i>Significant Results from Univariate Analysis of Variance (IVs=Disability Type, Competition Level, Sex and Disability Severity)</i>								
	Disability Type				Competition Level			
	<i>df</i>	<i>F</i>	η	<i>p</i>	<i>df</i>	<i>F</i>	H	<i>p</i>
Milestones								
1 st participation in wheelchair basketball	1,30	6.92	.19	.01	1,19	5.55	.23	.03
1 st participation in unorganized practice	1,30	5.80	.16	.02				
Stopped activity in other sports								

Notes. *df* = degrees of freedom, *F* = F value, η = *partial* η^2 , *p* = p-value, IVs = independent variables

Only models with a significant result are reported in this Table

Table 5*Overall Multivariate Model's Contribution to the Variability of Each Dependent Variable*

Milestones	Adjusted R^2	Model Contribution (%)
1 st participant in unorganized practice	.528	52.8%
1 st participation in wheelchair basketball	.502	50.2%
Age athletes established close relationship with coaches	.402	40.2%
Age athletes stopped involvement in other organized sports	.335	33.5%
1 st participation in deliberate practice	.279	27.9%
Age athletes started devoting all their leisure time to wheelchair basketball	.092	9.2%

Notes. The fixed factors in the model were: '*disability type*', '*competition level*', '*sex*' and covariate factor was: '*disability severity*'.
Adjusted R^2 = Proportion of the variation of dependent variables (milestones) explained by the aforementioned independent variables

Table 6*Mean Age Each Milestone was Reached per Competition Group*

	Junior	Precocious	Senior
Milestones			
1 st participation in wheelchair basketball**	12.88(3.18)	12.00(4.45)	16.67(5.55)
1 st participation in unorganized practice*	13.76(3.17)	12.86(4.19)	16.80(5.34)
1 st participation in deliberate practice**	14.59(2.45)	13.79(3.62)	17.86(5.18)
1 st participation: junior national competition	15.38(2.22)	15.08(2.63)	16.57(3.44)
1 st non-sport specific training (e.g., weight training)*	14.94(2.82)	14.25(1.22)	17.35(4.61)
Became regular player: junior national competition	15.22(2.54)	15.29(1.22)	17.35(4.61)
Idea of becoming elite athlete emerged**	14.19(3.29)	14.00(3.16)	18.89(4.76)
Stopped activity in other sports	14.17(3.31)	15.50(3.51)	18.71(5.78)
Established relationship with coaches**	14.60(2.55)	14.40(1.78)	19.74(5.69)
Conscious decision to become elite athlete	15.29(2.49)	14.83(1.85)	20.10(4.45)
1 st participation: junior international competition	16.20(2.59)	16.86(2.12)	18.08(2.64)
All leisure time devoted to wheelchair basketball*	15.10(2.33)	15.22(2.68)	21.23(4.46)
Practice			
Initial hours devoted to unorganized practice	3.88(3.12)	4.23(4.85)	6.11(6.43)
Current hours devoted to unorganized practice	4.31(3.82)	2.83(1.47)	3.69(2.91)
Initial hours devoted to deliberate practice	5.29(3.46)	7.92(6.44)	9.05(8.22)
Current hours devoted to deliberate practice**	6.40(5.36)	12.12(7.83)	18.08(8.27)

Notes. * $p < .05$. ** $p < .01$.

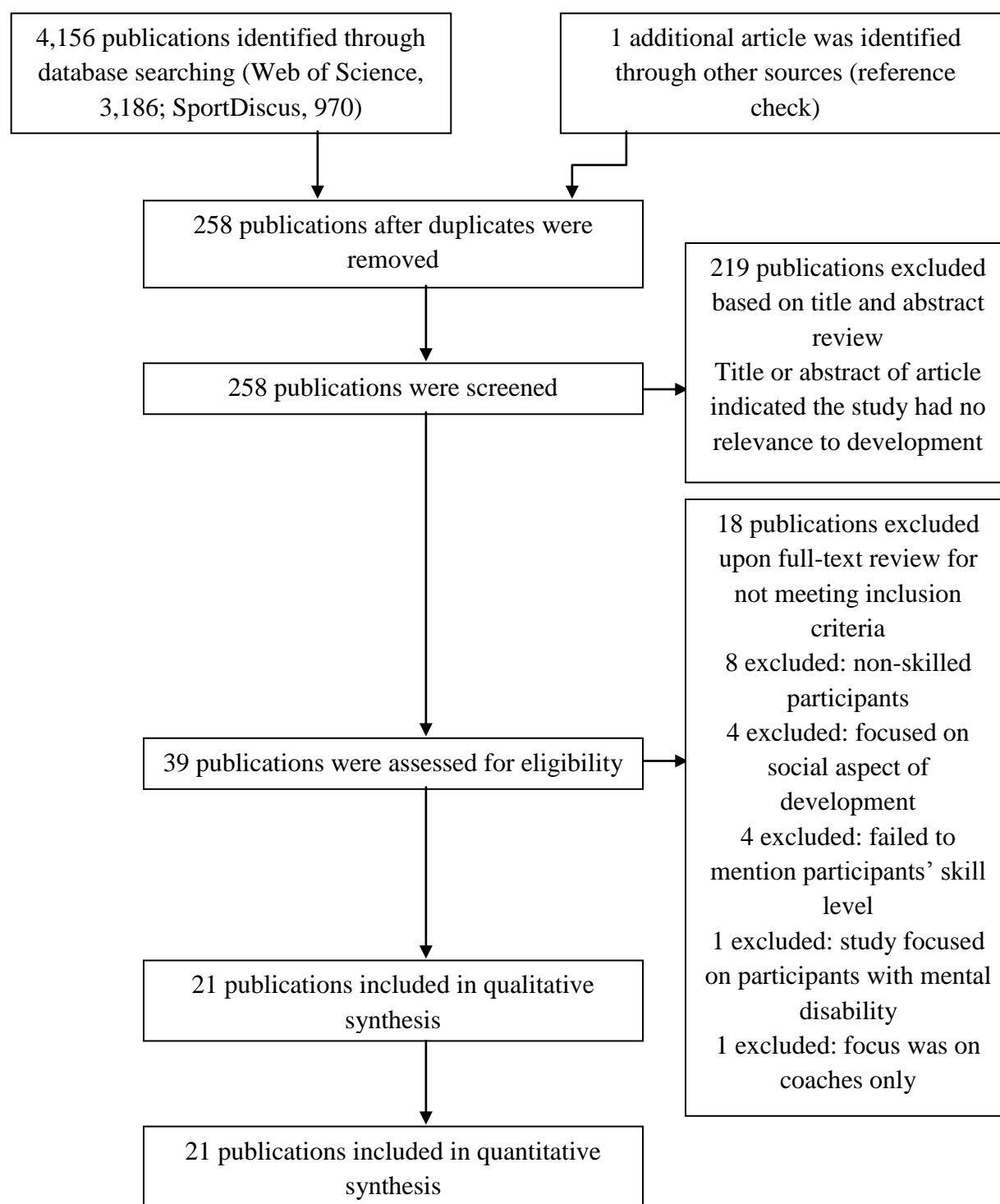


Figure 1. Phases of data retrieval, as per the PRISMA statement (Moher et al., 2009).