Insights Into Experiences with Myoelectric Training and Evaluation of a Novel Device: Perspectives of Clinicians in Pediatric Myoelectric Rehabilitation

By

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Dedication

To my family and Kevin,

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Abstract

Introduction Children with upper limb amputations face substantial challenges in daily life, often compounded by emotional and social difficulties. While myoelectric prostheses offer independence, their complex control demands extensive training and mental effort. Pre-prosthetic training is crucial for effective use, yet the absence of extensive pre-prosthetic training is one of the main causes contributing to high abandonment rates among users, particularly pediatric users. Despite efforts to enhance engagement through simulations and games, existing approaches lack tailored training plans for children with upper limb differences.

Methods At the Rehabilitation Centre for Children (RCC) in Winnipeg, Manitoba, a novel device that integrates EMG signals into training activities aims to enhance children's engagement. To assess the interest in using this device for clinical training, this study evaluated clinicians' perspectives. Through descriptive surveys, we gathered insights into training experiences and perceptions of myoelectric training from clinicians with relevant expertise in pediatric myoelectric training. Responses were analyzed using a multiple case study approach.

Results Five clinicians (prosthetists and one occupational therapist (OT)) with 4 to 30 years of experience participated. Family involvement emerged as a key factor, influencing decisions around training and ongoing prosthesis use. Training was described as both interdisciplinary and child-centred, with prosthetists mainly leading signal training and occupational therapists supporting functional training. Clinicians emphasized the use of play-based, age-appropriate activities to keep children engaged. However, there was considerable variation in how training was delivered, including differences in session length, timing, and assessment methods, with most relying on clinical judgment rather than standardized

measures. The novel device was generally seen as a useful way to enhance engagement through real-time feedback.

Conclusion Pediatric myoelectric training is highly individualized and influenced by family factors, such as parent involvement, time availability, geographic distance between the rehabilitation centre and the child's home, and the child's motivation, as well as clinician factors, including clinical experience and training approaches. More standardized approaches and the use of engaging technologies may help improve training outcomes and support long-term prosthesis use.

Glossary

Electromyography (EMG): The recording of electrical activity produced by muscles (Falk & Sejdić, 2018).

Signal training: Training that teaches users to generate the muscle signals needed to control a myoelectric prosthesis.

Control training: Training focused on learning to operate a prosthesis through specific muscle contractions. This may include games or virtual activities and may also be referred to as game-based training.

Functional training: Training that focuses on performing meaningful daily activities using a prosthesis.

Independent training: Myoelectric training completed without direct clinician supervision, such as home-based practice.

Virtual reality (VR): A computer-generated environment with scenes and objects that appear realistic, creating the feeling of being immersed in the environment (The Editors of Encyclopaedia Britannica, n.d.).

Augmented reality (AR): An interactive experience that enhances the real world by adding computer-generated perceptual information (Azuma, 1997).

Myoelectric prosthesis: A powered prosthesis that uses motors and batteries for movement. The device is controlled by electrical signals generated by muscles in the residual limb.

Table of Contents

Abstract iv

Glossary……...……...…...…..vi

Table of contents……..…….....vii

List of tables…….....…ix

List of figures…….……....x

Chapter 1: Background .....….1

Chapter 2: Literature review 10

2.1 Pre-prosthetic training.....15

2.1.1 Computer-based myoelectric training.....15

2.1.2 Pre-prosthetic training using toys 17

2.1.3 Pre-prosthetic training with mobile games 18

2.1.4 Pre-prosthetic Virtual and Augmented Reality Training 19

2.2 Post-prosthetic training 23

2.2.1 Robotic-assisted training.....23

2.2.2 Virtual reality training.....24

2.2.3 Perception of Researchers and Participants on engagement in myoelectric training 25

2.3 Summary 26

Chapter 3: Problem statement……...……...28

Chapter 4: Purpose & Objectives of the Study…….……29

4.1 Research purpose……...…….29

4.2 Research objectives.....……29

Chapter 5: Methods.....30

5. 1 Research approach 30

5.2 Participants.....30

5.2.1 Population and sample 30

5.2.2 Recruitment and inclusion criteria 31

5.3 Survey 31

5.4 Validity……...32

5.5 Data Analysis…….……33

5. 6 Data Storage……..34

Chapter 6: Results…..……..……..……..35

6.1 Individual Case analysis……..……...35

6.1.1 Case one……..……...….35

6.1.2 Case two……..……....36

6.1.3 Case three……..……..…...….39

6.1.4 Case four…...……...……....41

6.1.5 Case five… ……...……..…….……..…....43

6.2 Cross-case analysis……..……...……..…..……46

6.2.1 Demographic analysis……..…..……. 46

6.2.2 Training approach……...…….……... 48

6.2.3 Structure and delivery of training……...……... 51

6.2.4 Training activities and strategies ……..……..…52

6.2.5 Beliefs……...…….……. 53

6.2.6 Clinical decision making ……...…..……...57

6.2.7 Assessment measures to assess progress in training …….….58

6.3 perceptions of the novel device……..……..……. 58

Chapter 7: Discussion……..……...…....…....……60

7.1 Lack of standardized approach……...……..…….....60

7.1.1 Myoelectric training structure…….61

7.1.2 Independent training……61

7.1.3 Assessment measures to determine readiness to receive a myoelectric prosthesis…….62

7.2 Child-centred approach……...……...…….……..63

7.2.1 Play-based approach……...…….64

7.2.2 Engagement……...……..65

7.2.3 Functional training and early training:……...…….....….…….. 66

7.3 Family-centred care… …… ……..…....……..66

7.4 Interprofessional approach…….…….…...……68

7.4.1 Division of, and collaboration within, professional roles……...……68

7.5 Perceptions of the novel device……..…….....……69

7.5.1 Perceptions of the novel device usefulness……..……..…….69

7.5.2 Perceptions of the novel device's engagement……..……..70

Chapter 8: Conclusion……...……..…….…….....72

8.1 Strength and limitations…...…….....…….73

Chapter 9: Future research……...……74

Chapter 10: Knowledge Translation Plan.....….75

References.....……76

Appendix: Clinicians'questionnaire……...……...……...95

List of tables

Table 1. Studies focusing on myoelectric training……...……...11

Table 2. Summary of results……45

List of figures

Figure 1. Participant's profession …….46

Figure 2. Years of experience in myoelectric training.....47

Figure 3. Clinicians' involvement in training steps.....47

Figure 4. Time of training onset..... …….49

Figure 5. Age of training initiation 49

Figure 6. Session length.....50

Figure 7. Independent training length.....50

Figure 8. Functional training frequency.....53

Figure 9. Functional training tasks.....53

Figure 10. Prosthetic training difficulty.....55

Figure 11. Signal training difficulty.....55

Figure 12. Prosthetic control during training.....56

Figure 13. Prosthetic control complexity during control training.....56

Figure 14. Control training difficulty.....57

Figure 15. Functional training difficulty.....57

Chapter 1: Background

Research has shown that children with upper limb differences face not only physical challenges but also significant social and emotional difficulties. Research shows that children with congenital upper limb differences experience heightened stress due to upper limb differences (Franzblau et al., 2015; Johnson et al., 2015). Daily challenges stem from decreased hand function and visible differences in appearance compared to their peers, which can affect their social interactions (Thompson & Kent, 2001). Studies by McDougall et al. (2015) and Hatzenbuehler et al. (2013) highlight that these children often encounter unfavourable peer reactions, such as social stigma and rejection. These negative experiences, including intimidation and ridicule, can severely affect their psychological, emotional, social, and spiritual well-being. Thus, children with upper limb differences experience a range of challenges that significantly impact their daily lives and overall well-being.

Despite the significant challenges faced by children with upper limb differences, the prevalence of this condition is relatively low. Congenital upper limb differences occur in about 3.9 to 6.2 per 10,000 total births (Mano, 2020, p.15). In Canada, about 277,000 individuals have limb differences (Lambrinos & Xie, 2016). Approximately 5.6 million Americans are living with limb loss or limb difference (Ziegler-Graham & MacKenzie, 2024). While this population is small, the need for targeted support and resources is significant.

Understanding classifications and associated aetiologies is crucial for informing treatment and intervention strategies aimed at improving outcomes for individuals with congenital upper limb differences.

In the pediatric population, most upper limb differences (ULDs) are congenital rather than acquired, and congenital abnormalities are the most common cause for limb difference in children under the age of ten (Egermann et al., 2009; Kelly et al., 2009; Krebs et al., 1991).

Despite extensive research, the etiology of congenital ULD remains unclear. However, studies suggest that one-third have no known cause, one-third are hereditary, one-third are vascular, and a small proportion are attributed to exposure to teratogenic substances (Kelly et al., 2009). The International Organization for Standardization (ISO)/International Society for Prosthetics and Orthotics (ISPO) classify a congenital ULD based on the location at were the limb ends, either above or below the elbow (Farr et al., 2018, p.2). Among these classifications, proximal forearm truncation (below the elbow) is the most prevalent, followed by trans carpal, distal forearm, and brachial region above the elbow.

As children enter the second decade of life, trauma and illness become more prominent causes of limb differences, with tumours being the most frequent cause for disease-related ULD in the 10–20-year age group. Injuries related to automobile and lawnmower accidents are identified as the primary reason of acquired ULD in young children, particularly between the ages of 1-4 years, with rural children being more susceptible to injuries from agricultural tools and power lines (Hostetler et al., 2005).

In cases of congenital ULD, assembling a comprehensive rehabilitation team is essential. This team typically includes the child, their parents, a physician, an occupational therapist (OT), and a prosthetist (Kelly et at., 2009). The team conducts a thorough history and physical examination to evaluate past and present functional abilities, leisure activities, and interests, as well as parental and child objectives for prosthetic rehabilitation. Canadian pediatric rehabilitation programs, such as the Limb Difference Clinic at the Rehabilitation Centre for Children, use a multidisciplinary, family-centred approach that integrates prosthetic management with therapeutic interventions and individualized functional goals (RCC, n.d.).

Parents play an essential role in their child's prosthetic rehabilitation, significantly influencing decision-making and collaborating both within the family and with healthcare

professionals. This role is complex, involving emotional judgments that weigh the benefits and the child's future needs (Allen et al., 2014; Bradbury et al., 1994; Johnson et al., 2018). In addition to making critical decisions, parents support their child's treatment in daily life by assisting with everyday activities, guiding social interactions, coordinating information, and acting as an extension of the healthcare team (Sims et al., 2021). Therefore, parental involvement is crucial in ensuring effective prosthetic rehabilitation and optimizing outcomes for the child.

Moreover, parental concerns significantly influence prosthesis prescribing, and their support is essential for successful training (Krebs et al., 1991). Parents are responsible for attending to the child's daily needs and supporting them through mistakes, with OTs working closely with them to teach new techniques (Hermansson, 1991). Successful pediatric rehabilitation of children with ULD requires active parental involvement. Parents must attend and participate in treatment sessions to support their child's well-being, be educated on effective assistance methods, and receive a home program to improve prosthetic-wearing endurance and promote use (Krebs et al., 1991). Additionally, parents need training in using, managing, and maintaining their child's prosthesis. For children with acquired amputations, parents receive a post-surgery and prosthetic care plan, including residuum care and exercises to maintain range of motion (ROM) and muscle strength. Thus, comprehensive parental involvement and education are crucial for optimizing pediatric prosthetic rehabilitation outcomes.

Rehabilitation program planning should encompass goal setting, prosthetic reasoning (i.e., encompassing the rationale behind prosthetic selection and utilization), definition of a pre-prosthetic program, providing prosthetic training, and establishing a follow-up plan to ensure the prosthetic fits well and functions properly (Kelly et al., 2009). This collaborative approach ensures that the child receives comprehensive care addressing their physical,

psychological, and social needs, ultimately enhancing their overall well-being and quality of life.

Treatment alternatives for children with ULD should be carefully selected, prioritizing predicted function, comfort, and aesthetic appeal, as highlighted by Krebs et al. (1991). It is crucial to balance the children's psychological and physiological demands against any potential sacrifice to their eventual functioning.

Furthermore, the prescription of a prosthesis should be individualized to meet the child's specific needs and goals, with a focus on mitigating limitations caused by upper-limb amputation (Esquenazi, 2004; Melton, 2017). Rehabilitation programs and prosthetic recommendations must be tailored to align with realistic patient goals, aiming to maximize function, as emphasized in a clinician summary from the Department of Veterans Affairs & Department of Defense (2014). This patient-centred approach ensures that treatment decisions and interventions are aligned with the individual needs and aspirations of children with ULD, ultimately promoting their well-being and quality of life.

Upper limb prosthetics are offered to individuals with ULD to help them overcome their challenges. These assistive devices substitute for hand function lost due to limb deficiency, regardless of the cause (Trent et al., 2019). Current prostheses include cosmetic, passive, and active options, with active prostheses encompassing body-powered and myoelectric devices.

A critical factor in prosthesis selection is the child's age, which indicates their readiness to use the device. The ideal age to fit an initial prosthesis for children with congenital limb differences is around six months, when the child can sit, and the prosthesis typically selected is a passive one (Shaperman et al., 2003). This passive device often includes a voluntary opening terminal device and supports gross motor development tasks, enables two-hand tasks, promotes symmetrical crawling, and establishes a foundation for

future prosthesis use (Kelly et al., 2009). An active device becomes appropriate as the child begins to perform basic grip-and-release actions with this prosthesis. At this stage, the child should have a more than five-minute attention span, be capable of understanding two-step directions, recognize that the terminal device can carry objects, attempt to extend the terminal device with the unaffected hand, and be willing to engage in occupational therapy for training (Kelly et al., 2009). This progression ensures that the prosthesis supports the child's developmental needs and enhances their functional abilities.

Active options such as the body-powered prostheses utilize a strap to capture movement from the proximal body, which in turn causes cable excursion (Imbinto et al., 2016). Hybrid devices, which combine features of both body-powered and myoelectric prostheses, are often employed for people with ULD above the elbow (National Academies of Sciences, Engineering, and Medicine [NASEM], 2017). These advancements in prosthetic technology offer varied solutions to meet the specific needs of individuals with ULD, improving functionality and user satisfaction.

Myoelectric prostheses are commonly recommended to address the absence of anatomical structure, restore bodily equilibrium, mitigate overuse of the non-affected upper limb, and enhance quality of life (Anderson & Bischof, 2014). However, despite their potential advantages, users often find myoelectric prostheses challenging to control (Biddiss & Chau, 2007; Engdahl et al., 2015) and limited in functionality (Biddiss & Chau, 2007a; Peerdeman et al., 2011). Therefore, while myoelectric prostheses offer significant benefits, they also present notable usability challenges that need to be addressed.

Electrically powered prostheses operate using motors driven by a rechargeable power unit. The most used control approach for these prostheses is electromyography (EMG) signals (Trent et al., 2020). An electromyogram (EMG) is an electrical signal produced by regular muscle contraction, with the signal's amplitude being proportional to the muscle's

level of contraction (Salama & Bakr, 2016). Myoelectric-powered prostheses operate via EMG signals generated by muscle contractions in the remaining limb (Chadwell et al., 2018; Marković et al., 2014). This control method allows for more intuitive and precise manipulation of the prosthetic arm, enhancing functionality and user experience. The use of EMG signals in myoelectric prostheses represents a significant advancement in prosthetic technology, providing users with greater control and improving overall prosthesis performance.

The muscle groups and neural pathways involved in operating myoelectric hands differ from those used to control natural hands (Bongers et al., 2012). Consequently, using these new muscles to open and close the hand may not be intuitive for the user, potentially requiring more mental processing time and resulting in longer response times (Kuiken et al., 2004; Kuiken et al., 2007). Therefore, while myoelectric prostheses offer advanced functionality, their use requires significant user adaptation, underscoring the need for comprehensive training programs to improve intuitive control and ease of use.

Myoelectric fitting requires mental preparedness and the capability to complete supervised training to generate sufficient myoelectric signals for optimal prosthesis control (Esquenazi, 2004; Farr et al., 2018). To use a myoelectric prosthesis, a child must possess the cognitive competencies required for controlling a body-powered prosthesis and the ability to consciously contract muscles on demand (Kelly et al., 2009). Early fitting is thought to enhance prosthesis proficiency as the child grows. Using a prosthesis promotes the utilization of the limb with differences, encourages balanced skill development between the two limbs, and a realistic-looking prosthesis enhances self-perception and self-confidence (Kelly et al., 2009). Therefore, early fitting of a myoelectric prosthesis, when the child is cognitively ready, can significantly benefit the child's overall development and skill integration of a prosthesis.

According to Rekant et al. (2023), the top three priorities in myoelectric prostheses for people with upper-limb amputations are ease of use, meeting user needs, and cost (if not covered by the funding system). In addition, the authors identified the most important tasks that individuals with amputation desired were eating, bathing, dressing, using the restroom, transferring, leisure activities, manipulation tasks, carrying/grasping tasks, and housework.

In the pediatric population, upper limb prostheses may be abandoned by the child if they do not improve function (Kelly et al., 2009). Abandonment rates for these devices are estimated to be between 20% and 40% among users (Rekant et al., 2023). Specifically, mean abandonment rates for body-powered and myoelectric prostheses in children are reported as 5% and 35%, respectively (Rekant et al., 2023). These statistics highlight the importance of ensuring that prosthetic devices are functional and well-suited to the needs of children to reduce abandonment rates.

Children fitted with body-powered or myoelectric prostheses are more likely to continue using their device for longer than three years compared with children who use passive prostheses (Shida-Tokeshi et al., 2005). Additionally, children receiving their initial prosthesis before reaching age two have decreased abandonment rates (Farr et al., 2018), which highlight the significance of early fitting and the selection of more functional prosthetic options to enhance long-term acceptance and usage in young patients.

A child's prosthetic components should offer functional advantages while minimizing issues related to weight or operational difficulty. Research indicates that the most common reasons for rejecting upper-limb prostheses among pediatric and young adult populations are their failure to assist in function and lack of comfort (Sims et al., 2021; Wagner et al., 2007). Furthermore, proper training in the use of myoelectric prostheses significantly influences a person's acceptance and utilization of the device (Ballance et al., 1989; Millstein et al., 1986). Therefore, to reduce abandonment rates and increase the acceptance of upper-limb prosthetics

among children, it is crucial to ensure these devices are both functional and comfortable, with a strong emphasis on comprehensive training.

Myoelectric prosthetic training encompasses three key components: signal, control, and functional training. *Signal training* includes presenting the individual's electromyograph (EMG) signals, facilitating the activation, isolation, and connection of individual muscles to desired actions. *Control training* focuses on users learning to use their muscles appropriately through active feedback systems, such as computer simulations or games, thereby enhancing muscle isolation and task execution. *Functional training* teaches users to utilize the actual prosthesis for daily activities, progressing from basic motor skills to advanced tasks. Signal training, occurring pre-prosthetic, does not require the use of myoelectric prostheses, while control and functional training, considered post-prosthetic, occur after receiving the prosthesis. This comprehensive approach ensures users develop the necessary skills to effectively integrate myoelectric prostheses into their daily lives, ultimately enhancing their functionality and quality of life.

An evidence-based training goal for prosthesis users should be to optimally enable skill acquisition, improve performance with the device in training and facilitate skill transfer to normal life circumstances. Learning to operate a prosthesis involves motor learning, commonly defined as lasting changes in behaviour resulting from practice (Schmidt et al., 2019). Controlling an active prosthesis is challenging, and users often encounter difficulties, leading to reduced device acceptance (Bandara et al., 2012). However, it has been demonstrated that adequate functional training can significantly increase the acceptance rate of myoelectric prostheses in adults (Stein & Walley, 1983). Therefore, a comprehensive and effective training program is crucial for improving the usability and acceptance of prosthetic devices.

Task-dependent training, involving extensive repetition, is often essential for successful skill development and persistence, although it can be time-consuming and demanding. This prolonged process may lead to decreased motivation to continue therapy, potentially resulting in individuals giving up on their prostheses. Research suggests that heightened motivation and engagement in rehabilitative exercises can assist individuals in actively participating in and adhering to their therapy programs (Zhou et al., 2021). Therefore, enhancing motivation and engagement in rehabilitation activities is crucial for ensuring sustained commitment to prosthetic use and maximizing the benefits of therapy.

Chapter 2: Literature review

In this section, I will detail the current myoelectric training methods. The myoelectric training methods employed in various studies are categorized based on their software and hardware implementations, as well as their application in either pre-prosthetic or post-prosthetic training. I will first discuss pre-prosthetic training methods, followed by the post-prosthetic training methods.

Table 1 summarizes information from studies focused on myoelectric training. Each article presents a new method of myoelectric training, detailing the study design, participant details, training method, and results.

Table 1

Studies Focusing on Myoelectric Training

Authors	Study Design	Number of participants	Training	Intervention	Intervention Frequency	Outcome Measures	Result
Dupont & Morin (1994)	Correlation design	15 healthy participants (mean age 27 y.o.)	Pre-prosthetic training	Training sessions with three levels of difficulty	Twice a week, two weeks (ten days in total)	Control Time, training difficulty	Greater task difficulty resulted in longer completion times and increased control errors
Clingman and Pidcoe (2014)	RCT	Eight healthy adults (mean age 27 y.o.)	Pre- and post-prosthetic training (Signal, control, and functional training)	6, 1-hour training sessions First 6 sessions once a week then last session After 90 days	Myoelectric training by controlling a toy automobile through an EMG system	Crashing accidents, muscle isolation ability, Perceived game difficulty, task completion time	Participants demonstrated improved performance, reduced errors and difficulty, and increased enjoyment and confidence over time.
Winslow et al. (2018)		12 healthy participants	pre-prosthetic training	Myoelectric training playing dinosaur-themed games of varying difficulty levels	user experience, motivation, overall usability	User Evaluation Survey (UES), general user experience, enjoyment, competence, time, muscle control, muscle isolation	Training improved user experience, enjoyment, motivation, basic muscle control, and muscle sequencing abilities, with increased engagement in specific games.

Boschmann et al. (2021)	Pre-post experimental design	13 Participants (12 healthy and 1 with dismelia)	Pre-prosthetic training	Virtual prosthesis training sessions	6 sessions, 20 minutes	Subjective experience: difficulty of tasks, fun, motivation, perceived usefulness, the number of pins transferred, time limits	AR training enhanced enjoyment and significantly improved real prosthesis performance, demonstrated by increased successful pin transmissions following training
Anderson (2014)	Correlation design	12 healthy adults	Pre-prosthetic	AR-based training system that uses muscle contractions to control a virtual arm and play the game *Space Armada*	5-minute sessions	Users' subjective experiences, including enjoyment, competency, effort, and tension.	Participants preferred the ARM Trainer, reporting greater enjoyment and proficiency, lower effort, and reduced physical and cognitive tension compared with the Myoclone.
Prahm et al. (2017)		14 healthy adults, three sessions: one pre and one post-gaming on the same day, follow-up session two days later14	Pre-prosthetic training	Video-game based training	Peak muscle contraction, precise and isolated electrode activation, durability control	Fluctuations of EMG signals, Muscle control, muscle fatigue, enjoyment, perceived competence.	Training improved electrode activation, muscle signal separation, and endurance control; participants particularly enjoyed collecting items and challenging gameplay.
Nishino et al. (2017)		Five healthy participants were between	Pre-prosthetic training	A pick-and-place task picking up a virtual object with the virtual	Completion time of tasks, number of successful transfers	Success rate in executing the task and the	Higher success rate (97%) with real prosthesis compared to virtual prosthesis (22%).

		22 to 24. Two tasks Five times		prosthesis and placing it on another place		time taken to complete it.	Longer completion time with simulator (26.24 seconds) than actual prosthesis (7.94)
Hashim Et al. (2021)	RCT	10 Participants 5 healthy, 5 with trans radial amputation (2 congenital 3 traumatic amputation) All adults	Pre prosthetic training using a forearm band	Video games 4 video games Crate Whacker, Race the Sun, Fruit Ninja, and Kaiju Carnage	10 1-hour sessions over 4 weeks	Maximum voluntary contraction, virtual BBT test, Basic EMG test, IMI (intrinsic motivation inventory) test, User evaluation survey	Training improved virtual task performance, muscle strength, muscle activation and coordination, while participants reported high motivation, enjoyment, and perceived usefulness.
Aydin et al. (2022)	RCT	Eleven adults with upper limb amputation. Five one-hour sessions over five days	Post-prosthetic training		Training using an ArmeoSpring robot	"A-goal hand–path ratio, A-goal deviation, A-goal inconsistency, and A-motion assessed by the therapy robot" p.2	Treatment improved movement efficiency and stability, with significant reductions in hand-path ratio, deviation, and instability scores; improvements were greater in the robotic training group than in the control group.
Perry et al. (2018)	Correlation design	Thirteen active-duty military personnel with	Post-prosthetic training	To follow the motions of a virtual avatar using residual and phantom limbs		electrical activity from the residual limb,	Training improved classification accuracy and active motor function, with motor scores increasing

	UE loss (14 limbs). Twenty half-hour inactive sessions over 1 to 2 months.				performance accuracy	significantly over successive sessions.
Garske et al. (2021)	14 participants with limb differences and 12 researchers	Not applicable	Survey	-	Participants' preferences and thoughts about games in general and games in prosthesis training in particular	-

2.1 Pre-prosthetic training

In this section, I will focus on studies related to pre-prosthetic training, including signal training for children.

2.1.1 Computer-based myoelectric training

A computer-based system, the Myoelectric Control Evaluation and Training System (MCETS) have been employed to teach and assess the use of myoelectric hand prosthesis, particularly targeting young children (Dupont & Morin, 1994). This MCETS was designed with engaging visuals and audible incentives to enhance its appeal during myoelectric control exercises. In their study, 15 healthy adults (12 men and three women) with a mean age of 27 years and no prior experience in myoelectric training, participated in assessments over 10 days. These assessments involved training sessions featuring 12 tasks at varying difficulty levels, with performance evaluation focusing on the wrist flexor and extensor muscles by recording activity. This research provided support for the potential of MCETS as a tool for teaching and evaluating hand prosthesis use, particularly for children's upper limb myoelectric training.

The authors investigated the outcomes of myoelectric hand prosthesis training tasks, revealing four task-related reactions: suitable (correct function selection), undershot (stopping before the target), overshot (continuing beyond the target), and co-contraction (selecting both functions). Results indicated increased control time with greater difficulty, notably between easy and medium levels ($p = 0.0105$), alongside a rise in undershots and overshots as difficulty increased. However, overall task completion time decreased across all difficulty levels, highlighting training program effectiveness in improving myoelectric control skills.

The Dupont and Morin (1994) study showed a decreased time needed to complete the game; however, it did not follow up on how this result translated to the use of the myoelectric

prosthesis in everyday scenarios. While the research demonstrated a reduction in the time required to complete the game, suggesting improved control abilities among participants, it did not address the translation of these findings into real-life situations involving the use of myoelectric prostheses. Additionally, the study primarily involved healthy adult participants, raising concerns about the generalizability of the results to young children. Despite these limitations, the study concluded that the results indicated improved control skills, suggesting the effectiveness of the training methods. This study suggests that MCETS holds promise as a valuable tool for evaluating and training children with upper limb loss who use myoelectric hand prostheses. However, further research is needed to validate its effectiveness in practical settings and among all populations, especially the pediatric population.

Hashim et al. (2021) investigated the integration of video games into upper limb training. As they examined the impact of video games on muscle coordination, preparation, and motivation. The study included 10 participants with a mean age of 26.3 years, five healthy adults as controls, and five participants with a transradial amputation, three of whom had traumatic amputations and two of whom had congenital upper limb differences. In addition, none of them had experience with a prosthesis beforehand.

Participants completed 10 1-hour training sessions over four weeks using EMG-controlled video games connected to a Myo armband. The intervention included four games: *Crate Whacker*, *Race the Sun*, *Fruit Ninja*, and *Kaiju Carnage.* The training involved different muscle activation patterns such as fist making, waving, rotation, and double tapping. To evaluate the effectiveness of the intervention, the authors used maximum voluntary contraction (MVC), EMG assessments, virtual box and block test (BBT), and two surveys, including the Intrinsic Motivation Inventory (IMI) and the User Evaluation Questionnaire.

MVC and EMG assessments primarily captured the ability to generate and regulate myoelectric signals, whereas the virtual Box and Block Test assessed functional dexterity and task performance. The IMI and user evaluation questionnaire provided insight into motivation and user experience. Together, these measures capture different components of training outcomes; however, they do not comprehensively evaluate movement quality or real-world prosthetic use.

The results showed improvement in muscle strength and coordination over the training period. A significant positive association was reported between training duration and BBT scores ($r = 0.95$, $P < .001$). In addition, participants reported high levels of interest, perceived competence, usefulness, and motivation and low levels of pressure and tension during training. The authors concluded that video game-based EMG training may enhance engagement and motivation while supporting motor learning and muscle development. In addition, the study highlighted that engaging elements such as scoring, feedback, and interactive gameplay maintain participants' interest during training.

2.1.2 Pre-prosthetic training using toys

Playing with actual toys could make the repetitive movements in myoelectric training more enjoyable and motivating, leading to better engagement and consistency as compared to computer-based programs. Clingman and Pidcoe (2014) investigated the effectiveness of pre-prosthetic myoelectric training using physical objects, particularly toys, to develop skills in myoelectric control strategies and muscle isolation in upper limb prostheses.

The study involved eight healthy adults (mean age: 27) who controlled a toy automobile via an EMG system to navigate a slalom course. Results indicated significant improvements over time in various outcome measures, including shorter course completion

time, reduced subjective difficulty, errors, and turnarounds during training sessions. Participants demonstrated enhanced muscle control, particularly in steering the car, with superior performance across short weekly sessions and within successive muscle groups during a single session. They also reported higher interest and enjoyment in the game ($p < 0.01$), felt more proficient ($p < 0.01$), experienced less effort ($p < 0.01$), and had reduced anxiety and stress ($p < 0.05$) over the six sessions.

The study highlighted the positive impact of myoelectric control training on muscle control but acknowledged the need for more sophisticated methods for functional training. The limitation of including only able-bodied adult participants was also noted, suggesting that the results may not fully translate to children with upper-limb differences.

2.1.3 Pre-prosthetic training with mobile games

Myoelectric training using mobile games can be used for training without a clinician, and the person can perform various game tasks, possibly making training more engaging and fun. Winslow et al. (2018) proposed an innovative method for pre-prosthetic training called ADAPT-MP, which integrates a wireless wearable electromyography (EMG) band, training games, and an EMG provider website for definition and progress monitoring. The study involved 12 able-bodied participants who engaged in training sessions though dinosaur-themed games of varying difficulty. User experience was evaluated through surveys, motivation was evaluated using the Intrinsic Motivation Inventory (IMI), overall usability was measured via the System Usability Scale (SUS), and the User Evaluation Survey (UES) was used to assess the games in general, considering the interface and control mechanisms, as well as the drive to play.

Results indicated no significant differences in User Evaluation Survey (UES) responses before and after training, except for general user experience and degree of fun, with

Dino Sprint rated more favourably. Motivation levels significantly increased, associated with improved participant competence. Participants improved basic muscle control and sequencing, particularly in isolating flexor and extensor muscles during three-dimensional movements. Maximal EMG changes showed increased activation for basic, sequencing, and whole-arm movement tasks, but decreased activation in proportional control and isolation.

The findings suggest that the ADAPT-MP method is effective at enhancing myoelectric control skills, particularly in basic and sequencing tasks, and has positive effects on motivation and user engagement. The increased time participants spent on certain games, such as Dino Sprint and Volcanic Crush, indicates their effectiveness in engaging users and improving their skills. However, the lack of significant improvement in proportional control, the challenges in maintaining consistent usability throughout the training period, and the absence of children as participants highlight areas that need further research.

2.1.4 Pre-prosthetic Virtual and Augmented Reality Training

Virtual and augmented reality can be more engaging and motivating than playing mobile games for training. The immersive nature of VR and the interactive capabilities of AR provide a more engaging and realistic environment, which can lead to better training outcomes and could improve motivation and enjoyment in myoelectric training compared to computer-based training.

Many studies in myoelectric pre-prosthetic training have explored the use of virtual reality (VR) and augmented reality (AR) to develop immersive, interactive training settings, although research in this area has primarily involved healthy adults. Virtual and augmented reality (VR and AR) could enhance engagement, motivation, and enjoyment in myoelectric training, compared to traditional computer-based training.

The study conducted by Boschmann et al. (2021) investigated the effectiveness of augmented reality (AR) training in improving performance with myoelectric prostheses, focusing on the application of skills learnt in a virtual environment to real-world activities. In this study, participants used AR to control a virtual arm and perform tasks with a real prosthesis. The AR training was enjoyable and led to improved performance in tasks involving real prostheses. The researchers employed a pre- and post-test methodology, in which participants used EMG signals from their limbs to operate a virtual arm in AR and then performed tasks with real prostheses, specifically the Michelangelo hand by Otto Bock. 13 participants, including 12 healthy adults and one person with dysmelia, were involved in the study. Subjective feedback on the difficulty of real tasks, the enjoyment of AR training, and the perceived usefulness of visual force feedback was collected from participants. The study revealed that participants who underwent training between the pre-and post-test experienced fewer errors, rated the real prosthesis tasks as less difficult, and found the AR training enjoyable and motivating.

However, it is noteworthy that the participants were primarily healthy adults, with only one individual having an upper-limb difference. This limitation raises questions about the generalizability of the findings to the target population of individuals with limb differences. Despite the primarily healthy adult participant sample, Boschmann et al.'s study suggests that AR training can effectively improve performance with myoelectric prostheses and enhance user experience. However, further research involving individuals with limb differences is needed to confirm the applicability of AR training in real-world myoelectric training rehabilitation settings.

Anderson (2014) developed an AR-based platform, the ARM Trainer, for prosthetic myoelectric training. This platform gave users an instant mirrored display of themselves,

showing a virtual upper limb superimposed over their remaining limb. The primary aim was to train muscle control in a pre-prosthetic state, offering an engaging and effective training method. The study involved 12 healthy adults and focused on four muscle locations, evaluating users' subjective experiences, such as enjoyment, competency, effort, and tension. Participants' muscle activity controlled the virtual arm in a game to enhance muscle contraction. The virtual elbow was moved by contraction of the biceps and triceps and the forearm's flexor and extensor muscles. The game required participants to use muscle contractions to move virtual elbows and hands to shoot shots and destroy the spaceship. This setup demanded broad, quick movements when the area was far from the spaceship and precise actions when it approached the target, thereby teaching the control of muscular contraction through varying movement demands. The ARM Trainer's use of augmented reality for myoelectric training improved user experience and training outcomes. Positive feedback from participants suggests that the ARM Trainer could be an effective tool for pre-prosthetic training, offering an engaging and efficient method to control muscular contraction.

Prahm et al. (2017) performed research to assess the efficacy of virtual reality-enhanced training in enhancing various aspects of prosthetic motor control in people with ULD. 11 healthy participants without prior EMG control experience were evaluated on their maximum muscle contraction, accuracy, electrode activation isolation, and endurance control over 300 seconds. These assessments occurred in three phases: before playing three EMG-controlled games, after playing the games, and 2 days later for short-term retention evaluation. Participants completed user evaluation surveys after each game and an Intrinsic Motivation Inventory questionnaire at the end of the study.

This study demonstrated that virtual reality-enhanced training improved prosthetic motor control, fine motor accuracy, muscle isolation, and sustained control of the upper limb prosthesis. Moreover, participants reported greater enjoyment and applied more force during virtual reality training than with other myoelectric prosthesis training tools. Despite the slight increase in pressure during the sessions, participants preferred this method due to its engaging nature and the greater effort and enjoyment it elicited.

Prahm et al. (2017) suggested that virtual reality-enhanced training effectively improved various aspects of prosthetic motor control. Virtual reality training showed promise as a superior method for myoelectric prosthesis training, offering both improved technical outcomes and a more enjoyable, motivating experience for users.

A study by Nishino et al. (2017) introduced an augmented reality-based myoelectric prosthesis simulator, to evaluate its effectiveness in a pick-and-place task. The study involved five healthy participants aged 22 to 24 who used the AR simulator to grasp virtual objects. They also performed the same task with a real prosthesis to compare results. The study highlighted challenges in using the virtual prosthesis, particularly in estimating depth and perceiving the three-dimensional aspects of virtual objects. The lack of perceptible edges in the AR environment made it difficult for participants to perceive surfaces and move their hands effectively. The extended manipulation time for the virtual prosthesis suggested that participants made cautious, deliberate movements due to a lack of depth perception, resulting in slower task performance to minimize errors.

Nishino et al.'s (2017) study supported the importance of addressing depth perception issues in AR-based prosthetic simulators. Enhancing depth perception and the three-dimensional representation of virtual objects could significantly improve user performance and the overall efficacy of AR-based myoelectric prosthesis training tools.

In summary, virtual and augmented reality for pre-prosthetic myoelectric training has shown that participants feel more motivated, exhibit greater interest and proficiency, and demonstrate improved accuracy and precision. However, the impact on stress and pressure varies: some studies report reduced pressure and stress, while others report increased stress during sessions. Most research has involved healthy adult participants, making it challenging to generalize the findings to children with ULD. Additionally, no studies have followed up on prosthesis control after training to assess the long-term effects and impact of virtual and augmented reality training on prosthesis use.

2.2 Post-prosthetic training

Post-prosthetic training involves control and functional training following prosthesis receipt. This training assists individuals in mastering muscle-contraction control and using their prostheses for everyday tasks. Two studies focused on post-prosthetic training: the first study utilized robotics, and the second used virtual reality.

2.2.1 Robotic-assisted training

Robot training is usually used for rehabilitation after stroke and other neurological disorders; however, one study focused on robot-assisted myoelectric training. In the first study, Aydin et al. (2022) investigated use of movement therapy robots for robot-assisted training to enhance myoelectric prosthesis use. Participants aged 18 to 54, equipped with myoelectric prostheses, engaged in exercises simulating daily activities through a robot-assisted program. The robot-assisted exercise group participated in five 1-hour sessions over 5 days, while the control group received no specific training. The exercises in the robot-assisted group were designed as games, with outcome measures including trajectory computation, deviation from the target, and instability during goal assessment. The results

indicated no notable differences in initial characteristics between the two groups. Following robot treatment, there were no notable changes in move scores for either group. However, the mean percentage changes “in the hand-path ratio, deviation, and instability subscale scores” after training were notably greater in the robot-assisted group compared to the control group (P = 0.006 for all three subscales) (Aydin et al.,2022, p.7).

These findings suggest that robotic training may improve performance with myoelectric prosthesis use, as reflected in specific movement-related metrics. The authors posit that the increase in myoelectric prosthesis utilization observed among participants may be attributed to sensorimotor learning of the remaining muscle limb enhanced by robotic training. Participants showed improved performance metrics, suggesting proprioceptive motor learning was facilitated by robot-assisted exercise.

2.2.2 Virtual reality training

The second study explored the potential of VR in advanced myoelectric post-prosthetic control training. Perry et al. (2018) incorporated (VR) simulations into control training of myoelectric prosthetics for upper extremity motor rehabilitation. The study involved 13 individuals with upper limb differences who participated in 20 half-hour inactive motor training sessions in 1 to 2 months. During these sessions, participants followed a virtual avatar's movements while the electrical activity of their residual limb's was recorded. Additionally, eight participants finished 20 half-hour active motor training sessions, controlling a simulated avatar through increasingly complex movements and being scored on accuracy.

The researchers used a modified Intrinsic Motivation Inventory questionnaire to assess participants’ personal experiences of with VR interventions. The results highlighted a

notable enhancement in classification precision, underscoring the effectiveness of the VR training platform. The analysis of score progression through longitudinal mixed-effects linear regression provided a detailed understanding of participants' improvement over time. In conclusion, post-prosthetic training, including robotic-assisted and virtual reality methods, holds the potential to enhance individuals' prosthetic use in daily tasks.

2.2.3 Perception of Researchers and Participants on engagement in myoelectric training

Finally, it is important to evaluate and understand the perceptions, expectations, and experiences of people with upper limb differences and clinicians to develop a well-designed prosthetic training plan. Garske et al. (2021) investigated the perceptions of participants with upper limb differences, as well as researchers, clinicians, and trainees, regarding engagement in prosthetic game training. The study included 14 individuals with upper limb differences and 12 researchers involved in research and game-based training for prosthesis training. Survey results were categorized into usability, training, game design, and obstacles.

Three participants with limb differences and five researchers highlighted usability and game design issues. Both groups emphasized the importance of simplicity and reliability in the myoelectric training setup and usage. Individuals with limb differences anticipated benefits in musculature development and prosthesis dexterity improvement. Moreover, researchers sought faster learning speeds, training in activities of daily living, and the transfer of gaming skills to prosthesis use.

Compatibility with existing devices at home emerged as a central theme, with both groups expressing the need for an appealing in-home adaptation. Preferences included a gradual increase in difficulty, the ability to use both hands, and motivation to complete sufficient repetitions to form habits. The study suggested developing of a web-based gaming platform to address issues stemming from outdated components in the myoelectric control

research community. Overall, the findings underscore the importance of user perspectives in designing effective, user-friendly prosthetic game training systems.

2.3 Summary

Myoelectric training methods encompass various approaches aimed at improving the control and functionality of prosthetic limbs, both before and after receiving a prosthesis. Pre-prosthetic training methods include computer-based systems like the Myoelectric Control Evaluation and Training System (MCETS), which uses engaging visuals and incentives to teach myoelectric control skills. Physical object-based training, such as using toys, has also been explored, demonstrating improved engagement and muscle control in training sessions.

VR and AR have emerged as effective tools for both pre-and post-prosthetic training. VR simulations, as seen in studies by Perry et al. (2018) and Nishino et al. (2017), provide immersive environments that enhance user motivation, proficiency, and accuracy in controlling myoelectric prostheses. AR, as investigated by Boschmann et al. (2021) and Anderson (2014), provides real-time visual feedback and interactive training scenarios, further improving motor skills and user experience.

Post-prosthetic training often involves robotic-assisted methods, in which movement therapy robots enhance control of muscle contractions and prosthetic use. Studies, such as those by Aydin et al. (2022), highlight significant improvements in movement-related metrics and proprioceptive motor learning facilitated by robot-assisted exercises.

User-centred design principles, as emphasized by Garske et al. (2011), are crucial in developing effective and user-friendly myoelectric training systems. Addressing usability, game design, and home adaptation needs can optimize training outcomes and facilitate long-term skill retention and integration of prosthetic devices into daily life.

The literature demonstrates that myoelectric training methods are diverse and continually evolving, with the potential to improve functionality, engagement, and quality of life for individuals with upper limb differences. Employing a variety of technologies can facilitate the development of foundational skills necessary for effective prosthetic control. Across multiple studies, participants exhibited improvements in muscle activation, motor control, accuracy, coordination, and task performance, while also reporting increased enjoyment, motivation, and engagement. These findings indicate that integrating interactive and game-based elements into myoelectric training may enhance learning by making repetitive muscle training more engaging and by promoting sustained participation.

Despite these promising findings, several significant limitations persist. The majority of studies involved healthy adult participants rather than children with ULD, which restricts the generalizability of the results to pediatric populations. Sample sizes were consistently small, and few studies assessed whether training-related improvements translated into successful prosthesis use in daily activities or were sustained over time. Additionally, the literature predominantly focused on technical outcomes, such as muscle control and task performance, while offering limited insight into the experiences and perspectives of clinicians and families who implement or support myoelectric training. Another identified limitation is the lack of follow-up on the transfer of skills acquired during prosthesis training to actual prosthesis use. However, this aspect is beyond the scope of the current study and will not be examined here.

Chapter 3: Problem statement

While numerous studies have explored methods to enhance engagement through simulation with computer games, virtual reality, and physical toys, none have included children with ULD as participants, and most have offered limited training plans, primarily focusing on signal and control training. At the Rehabilitation Centre for Children in Manitoba, clinicians have developed a device to make pre-prosthetic training more engaging for children. This device can convert EMG signals into various tools and objects, such as toys, to make pre-prosthetic training more interactive and stimulating. By addressing the gap in existing research and offering a solution tailored to the needs of children with ULD, this innovative approach holds promise for improving engagement and outcomes in prosthetic training programs.

In this study, we sought to understand the perceptions, attitudes, and experiences of both parents of children with upper limb differences and clinicians to gain insights into the factors influencing children's use of prostheses, engagement in training, and overall training experience. The intent was to use the findings to inform clinicians on the development of a pre-prosthetic training program, integrating the RCC device, to enhance long-term engagement in the program and ultimately aim to reduce the abandonment rate of myoelectric prostheses.

Chapter 4: Purpose & Objectives of the Study

4.1 Research purpose

The aim of this study was to assess clinicians' perceptions, attitudes, and experiences in the field of myoelectric training, specifically focusing on their experiences with myoelectric training. Additionally, we introduced a device developed at the Rehabilitation Centre for Children and gathered participants' feedback on its potential impact if added to their training plan. While we originally planned to also assess parents' perceptions and satisfaction regarding their children's myoelectric training, exploring their level of involvement and participation in their child's myoelectric training, and evaluating their child's current prosthesis use, recruitment of the parent group was not attained for reasons outlined in the results.

4.2 Research objectives

The research objectives of this study included; 1) describing clinicians' current training methods, 2) examining their perceptions regarding the complexity and difficulty of each step in myoelectric training, 3) evaluating their session length and frequency, 4) exploring their perceptions of children's enjoyment and engagement, 5) determining the presence of independent practice (i.e., home-based practice without a therapist) in their myoelectric prosthetic training plan, 6) gathering clinicians' opinions about each step of myoelectric training, and 7) gathering their feedback about the new device designed at the Rehabilitation Centre for Children in Winnipeg, Manitoba.

Chapter 5: Methods

5.1 Research approach

We used a multiple case study approach. In this approach, each case is studied individually and then compared with other cases to identify common patterns, similarities, and differences, providing a deeper understanding of the phenomenon being studied (Stake, 2006). To gather data, we employed a descriptive survey to assess clinicians' perceptions of myoelectric training. According to Glasow (2005), surveys provide descriptions of existing phenomena and their contexts, which align with our research objectives. Surveys are used to efficiently and rapidly gather data from large populations (Ponto, 2015). Through surveys, we can gather a considerable amount of information in a short amount of time. Web-based surveys enable data collection from a wide, geographically diverse audience at low cost, enhancing efficiency and affordability. They offer greater anonymity and promote honest answers to sensitive questions (Sue, & Ritter, 2012).

5.2 Participants

5.2.1 Population and sample

The primary population of this survey was clinicians, including prosthetists, OTs, rehabilitation engineers, and physical therapists with relevant experience in the field of pediatric myoelectric prosthetic training across Canada. The participant group was asked to complete a survey tailored to their role and perspective.

5.2.2 Recruitment and inclusion criteria

We recruited clinicians, including occupational therapists and prosthetists, across Canada. The study flyers were distributed through the Orthotics and Prosthetics Canada (OPCanada) website (https://opcanada.ca/) and the Canadian Association of Occupational Therapists (CAOT) website. Both CAOT and OPCanada are national organizational websites, and many OTs and prosthetists are likely members of these organizations. We emailed occupational therapists via the CAOT Find an OT (a public site where members share their contact information and areas of specialization). In addition, we reached out to WARAMP and the Canadian Physiotherapy Association. Also, recruitment materials were sent to RCC staff, and potential participants were reached via snowball sampling. The criteria for clinicians included at least 2 years of experience in pediatric myoelectric training.

5.3 Survey

We employed a survey approach utilizing both open-ended and closed-ended questions. The survey was web-based, and a link was provided to potential respondents. We used REDCap, a web-based survey host, for development and data management. REDCap is a secure server REDCap (Research Electronic Data Capture) is a secure, web-based software platform accessed by UM researchers and is housed in the George and Fay Yee Centre for Healthcare Innovation designed to support data capture for research studies, providing 1) an intuitive interface for validated data capture; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for data integration and interoperability with external sources (*REDCap*, 2004).

The survey aimed to gather information on participants' experiences, attitudes, and perceptions regarding myoelectric training (see the Appendix for a copy of the survey). The

questions were generated from key factors identified in the literature and were developed in collaboration with and reviewed by experienced clinicians at the RCC in Winnipeg, Canada. Completion of the survey was expected to take approximately 15 minutes and posed no risk to participants. The University of Manitoba Health Research Ethics Board (HREB) reviewed and approved the study prior to data collection (HS26835; H2025:062).

The survey began with a request for participants' voluntary consent. The purpose of data collection and the potential risks were explained, and the confidentiality of responses was assured. Participants indicated their consent by checking a box. If participants did not consent, they would not proceed with the survey.

Close-ended question responses primarily used a Likert scale, which is commonly used to evaluate perceptions and experiences. This scale measures abstract aspects and subjective assessments. According to social exchange theory, most questions were closed-ended to reduce cognitive load and social costs and to improve response rates (Dillman, 2000).

To encourage participation, we offered both monetary and non-monetary incentives. One responder was randomly selected to receive a $25 Amazon gift card. After completion, an additional survey link was provided, allowing participants to enter their information for the draw.

5.4 Validity

To ensure content validity, the survey questions were developed based on a thorough review of previous literature that discusses and evaluates relevant data.

Additionally, the remaining survey questions were written in collaboration with clinicians, including an OT, PT, prosthetist, and a rehabilitation engineer who specializes in

myoelectric training at RCC. These clinicians provided insights based on their practical experience and expertise, ensuring that the questions were grounded in real-world practices.

To further enhance content validity, the survey questions were evaluated by experts from the RCC. These experts assessed each question to ensure it was directly relevant to the study's objectives, thereby excluding items that did not contribute to the intended research purpose.

Finally, we conducted a pilot test with a small sample from our target population to ensure that our questions effectively capture the research objectives. The pilot testing helped identify ambiguities in the organization of questions, survey structure, readability, and clarity, as well as issues with question wording, allowing for necessary refinements before the full-scale survey administration.

5.5 Data Analysis

Due to the small sample size, we analyzed responses using a multiple-case study approach. The data were analyzed using within-case and cross-case analyses informed by Stake's (2006) multiple-case study methodology. First, participants' responses were extracted from REDCap. Each participant's response was treated as an individual case, resulting in five case reports. For each case, the survey responses were read thoroughly to develop a deep understanding of participants' experiences and perspectives. Through within-case analysis, a description of each case was written, describing the clinician's training approaches, perceptions, attitudes, and clinical decision-making process.

As the survey was developed based on the research objectives, participants' responses were organized into sections relevant to the study questions, including demographics and

professional background, training approach, beliefs and perceptions, clinical decision-making, and perceptions of the RCC device.

Next, participants' responses were gathered into a document to facilitate comparison across cases. The responses were reviewed to identify similarities, differences, and common patterns. Cross-case analysis was conducted by grouping similar concepts and patterns, and recurring themes were identified across cases. Cross-case analysis allows researchers to discover commonalities and differences between cases and develop a deeper understanding of emerging themes across participants (Miles et al. ,2014).

The purpose of the cross-case analysis was to understand current pediatric myoelectric training approaches through multiple clinician perspectives, with the pediatric myoelectric training as the central phenomenon (Stake, 2006). Common patterns were identified and interpreted to develop assertions. According to Stake, assertions are evidence-based interpretations derived from analysis of cases and cross-case patterns. These assertions were used to better understand clinicians' current training approaches, perceptions, and experiences related to pediatric myoelectric training.

5.6 Data Storage

All data were stored in a secure Microsoft Teams account at the University of Manitoba, with access restricted to only researchers involved in the project who have completed PHIA and TCPS-2 training and hold relevant certifications. Furthermore, the collected data is stored on the REDCap server at the University of Manitoba, ensuring additional security measures and accessibility for authorized personnel only.

Chapter 6: Results

This section presents five case studies derived from participants' responses to the clinician survey. Each case is described individually, followed by a cross-case analysis to identify similarities, differences, and emerging themes.

6.1 Individual case analysis

6.1.1 *Case one*

Demographics and professional background Clinician one is a prosthetist with 11 years of experience. The clinician indicated that they felt they had received sufficient training and education to conduct myoelectric training. Signal and control training, using games and toys, was included in their rehabilitation approach. They began myoelectric training with clients at the when the prosthesis was acquired.

Training approach They stated that they started training children for congenital limb differences between the ages of 2 and 5 years. During the signal training, they assessed muscle isolation and muscle co-contracture. All their sessions were between 6 and 15 minutes. They used augmented reality and toys in games and systems used in myoelectric training. The specific game was Coapt control companion AI. They used objects of different sizes as toys during training sessions. In addition, they held two to three functional training sessions per week with a child, and the tasks included dual-hand tasks and exercises. Furthermore, the clinician reported that children might complete one to five training sessions without therapist's supervision.

Beliefs They strongly agreed that myoelectric training is an innovative approach that can lead to improved patient outcomes, although they disagreed that the training process is easy for children to learn. The clinician was neutral about difficulty of signal, control, and functional training and complexity of controlling the prosthesis during functional training. However, they perceived controlling the prosthesis during signal training as simple, and they perceived controlling the prosthesis during control training as complex and found children engaged in control training. In functional training, children were generally reported to be engaged during these sessions.

Clinical decision making They highlighted that they used a subjective assessment method to measure a child's readiness to receive a myoelectric prosthesis. Moreover, they assessed children's engagement during the appointment through conversation and preferred that they wear any kind of prosthesis to get started so they would be familiar with wearing something on their body.

New Device Clinician one didn't respond to the questions about the new device.

6.1.2 Case two

Demographics and professional background Clinician two is a prosthetist with 30 years of experience and outlined that they had received enough training to conduct myoelectric training. They reported being involved in signal training, control training with games and toys, and training in activities of daily living (ADLs). They started myoelectric training before acquiring the prosthesis.

Training approach They started myoelectric training for congenital limb differences before age 2 and noted that incorporating myoelectric training into treatment from the start of care is crucial. They reported using a different approach for trans-radial and trans-humeral patients. The duration of their training sessions ranged from 16 to 30 minutes. During signal training, they assessed muscle isolation and co-contraction using all relevant muscles, including the triceps, biceps, flexors, and extensors.

They explained that, in control training, they incorporated toys and computer games, including commercially available computer games and manufacturer-specific games, and used a diverse range of age-appropriate toys. They stated that functional training is conducted at each visit, with one session per week, focusing on age-appropriate activities such as hygiene, dual-hand tasks, exercise, homework, baking, and other engaging activities. Additionally, they stated that their treatment plan included independent training without therapist supervision, with children completing one to five sessions lasting 1-5 minutes each.

Beliefs They strongly believed that myoelectric training is an innovative approach that can lead to better patient outcomes and strongly agreed that it is easy for children to learn. They found signal training simple and observed that children remained engaged during these sessions, highlighting the importance of selecting appropriate activities. Similarly, they found children engaged in functional training and reported that it was easy for them to learn. In myoelectric training without a therapist, they noted that children demonstrate a moderate level of engagement.

Clinical decision making They noted that, together with an OT, they participated in first optimal site selection and then provided training using a variety of age-appropriate activities. They used the Assessment of Capacity for Myoelectric Control (ACMC), an observational tool that evaluates an individual's ability to operate a myoelectric prosthetic hand during daily activities, and the Prosthetic Upper Extremity Functional Index (PUFI), a

questionnaire completed by both children and parents to assess children's readiness to receive a myoelectric prosthesis. In addition, they assessed children's cognitive abilities and functional skills using an in-house myoelectric training unit to observe the relationship between muscle contraction and hand opening, noting that software could also be used for this purpose.

They evaluated children's progress in signal training by their ability to complete functional tasks in a timely manner and mentioned progress was assessed during training sessions through follow-up calls, in-person appointments, and virtual sessions. Regarding training materials, they stated that any toy capable of assessing suspension, electrode contact, and prosthetic control could be used.

New device Clinician two perceived the new device to be useful as they explained that the child could observe and hear the effects of their muscle contractions in real time. They believed that the device could enhance engagement in myoelectric training, as toys serve as a fun method to promote engagement in training and can be tailored to the child's age.

6.1.3 Case three

Demographics and professional background Clinician three is a prosthetist with 8 years of experience. They disagreed with the statement that they had received sufficient training and education on how to conduct myoelectric training sessions. They reported being involved in signal training and control training using games and toys. They initiated training with the child at the time of prosthesis acquisition.

Training approach They began myoelectric training for congenital limb differences between ages 2 and 5 years, using the same approach for trans-radial and trans-humeral patients. Their signal, control, and functional training sessions typically lasted between 6 and 15 minutes.

In control training, they used toys and reported using switch-adapted toys triggered by myoelectric signals. They expressed interest in exploring virtual reality and computer-based games. They further described using specific toys such as a bubble blower adapted with a switch or a wand that illuminates and spins.

Regarding functional training, the number of sessions varied depending on the patient, but they usually scheduled the child for two to three sessions before the prosthesis was delivered, with additional sessions scheduled based on the family's interest and motivation to attend. In addition, they conducted one functional training session per week after delivering the myoelectric prosthesis. Furthermore, they recommended one to five sessions of myoelectric training without a therapist, each lasting between 1 and 5 minutes.

Beliefs They stated that myoelectric training was neither easy nor difficult for children to learn. They reported that signal training was difficult for children and that controlling the prosthesis was complex, although they noted that children were very engaged during these sessions. Control training was rated as neither easy nor difficult, and controlling the prosthesis was complex for children. However, they noted that children were very engaged in these sessions.

During functional training, they observed that children were engaged, though they found controlling the prosthesis complex, noting that children tended to enjoy it more when it aligned with their interests and when they experienced success. They observed that children showed low engagement in myoelectric training without a therapist.

Clinical decision making They stated that they did not use a validated scale and that the decision about a child's readiness was made together with the OT and family. They focused mainly on family motivation and goals, including willingness to participate in training and prosthetic fittings. They secondarily focused on the child's muscle activation abilities, i.e, their ability to generate a myoelectric signal at one or two sites.

During signal training, they evaluated muscle isolation co-contraction in the triceps, biceps, flexors, extensors, and other relevant muscles. They explained how muscle testing is individualized based on each patient's amputation level or limb difference, for example, when intrinsic hand muscles are sometimes included for partial hand amputees. They assessed children's progress in signal training by their ability to generate signals with control, maintain signal duration, and perform co-contraction. For myoelectric training without a therapist, they assessed children's progress based on feedback from the child's family.

New device Clinician three perceived the device to be useful, explaining that they believed it would create a highly engaging environment for the initial stages of myoelectric training**.** They further believed that the device could enhance engagement in myoelectric training by being customizable to the child's preferences and interests.

6.1.4 Case four

Demographics and professional background Clinician four is a prosthetist with 14 years of experience in myoelectric training for children. They noted that they had started 26 years ago, but they no longer work with children. They did not agree or disagree that they received sufficient training, but they strongly agreed that myoelectric training is an innovative approach that leads to better patient outcomes. They started myoelectric training at the same time as acquiring a prosthesis.

Training approach They began myoelectric training for congenital limb differences around age 1 year, using the same approach for trans-radial and trans-humeral patients.

During signal training, they started with a single-site voluntary opening system, and used EMG signal from any forearm muscle; however, their challenge was to find the ideal location. Moreover, they stated that they used triceps, biceps, flexors, and extensors in signal training. They reported that their signal training sessions lasted between 6 and 15 minutes.

They used toys in control training and, they had access to a variety of toys, selected those children had chosen. However, clinician 4 did not respond to questions regarding the length, difficulty, complexity, and engagement of control training, explaining that they had only used a voluntary opening terminal device for the first prosthesis and would increase complexity in the next prosthesis. They reported that functional training sessions lasted between 6 and 15 minutes and that they scheduled a total of three to five sessions, held once a

week. Finally, they mentioned that their training approach did not include independent sessions without a therapist.

Beliefs They did not agree or disagree that myoelectric training is easy for children to learn. They observed that myoelectric prosthesis training was easy for children. They believed that controlling a prosthesis was easy for children during myoelectric training. However, they noted that the difficulty level depended on the child's age. Because training began around age 1, it may be easier for very young children. The clinician noted the child's age influenced the training process. Older children exploring their independence, the training was more difficult. As children matured and were better able to understand and follow instructions, the training became somewhat easier.

They started training with a single-site voluntary opening system. Moreover, they perceived signal training to be neither easy nor difficult. They found controlling the prosthesis during signal training simple, but engagement in signal training varied based on the children's attention span. Finally, they observed that children were neither engaged nor disengaged in functional training, that functional training was easy for children, and that it was the clinician's responsibility to make the functional training fun and interesting.

Clinical decision making They reported assessing progress in signal training by how long they could engage the child in play, indicating that the training and assessment were concealed as play, and they considered play successful when the child used the prosthesis during play.

In addition, they observed that the prosthesis use was impacted by many factors, including the family's engagement in play and the child's problem-solving skills, highlighting that using the prosthesis is only a small part of myoelectric training success.

New device feedback Clinician four commented on the device's usefulness, stating that they thought it would be useful in the myoelectric training process; however, they were unsure of whether it would increase children's engagement. They explained because they started training very early with very young children, they did not believe this device would be useful; however, they believed it would be very useful with older children.

6.1.5 Case five

Demographics and professional background Clinician five is an OT with 4 years of experience in pediatric myoelectric training. They described participating in myoelectric training using games or toys, as well as in ADLs. They stated that they started myoelectric training with children before they acquired their prosthesis.

Training approach In the case of congenital limb differences, training began between the ages 6 and 10. They used the same training plan for trans-radial and trans-humeral patients and used a child's ability to isolate and co-contract muscles to assess progress during signal training. Moreover, they used different muscles based on the level of amputation and individualized for each case. The length of their training sessions ranged from 16 to 30 minutes; however, the length of sessions varied based on the child's age and attention span. In addition, they used toys during control training, and the toy selection depended on the child's interest; for instance, they used blocks, peg boards, and cause-and-effect toys. However, currently, they do not use any systems or games.

For clinician five, the number of functional training sessions scheduled varied based on the child but was usually between one and three sessions. The frequency of sessions also varied, depending on whether the family lived in a remote area; if so, it was less than once a week. Their training included dual-hand tasks, homework, household chores, and personal care tasks such as dressing, individualized to each child. Finally, they stated that they did not

recommend independent myoelectric training sessions without a therapist present as part of their training approach.

Clinical decision making They described not using a standardized measure to determine readiness; instead, they consulted with the family and the prosthetist. They also assessed the family's readiness and the child's ability to focus on training sessions.

Beliefs They disagreed with receiving sufficient training; however, they neither agreed nor disagreed that myoelectric training is an innovative approach that leads to better outcomes. In addition, they believed that myoelectric training is hard for children to learn. They believed that controlling a prosthesis during training is neither easy nor difficult for children. Moreover, they found signal training neither easy nor difficult, and noted that controlling the prosthesis during signal training was complex for children. Overall, they found that children were engaged in signal training.

They described game training as difficult for children and noted that controlling the prosthesis during game training was complex. However, they found that children were mostly engaged in training; this depended on the child. They also reported that children were engaged in functional training despite the difficulty controlling the prosthesis during these activities. They observed that some children were more engaged than others.

New device They believed this device would be useful for training and explained that it could simplify the process. As they explained, it would allow the therapist to focus on training and muscle contractions rather than worrying about arm position or movement. In addition, they stated that this device would make training more engaging for children. They suggested that this device could be used with switch-adapted toys for younger children, and it could be attached to gaming controllers for older children.

Table 2

Summary of Individual Participant Responses.

Domain	Clinician 1	Clinician 2	Clinician 3	Clinician 4	Clinician 5
Profession	Prosthetist	Prosthetist	Prosthetist	Prosthetist	Occupational Therapist
Years of Experience in myoelectric training	11	30	8	14	4
Training steps	Signal, control, functional, independent	Signal, control, functional, independent	Signal, control, functional, independent	Signal, control, functional	Control, functional
Timing of Training Onset	At time of prosthesis acquisition	Before prosthesis acquisition, from start of care	At time of prosthesis acquisition	At time of prosthesis acquisition	Before prosthesis acquisition
Start of Training Age	2-5 years	Before age 2	2-5 years	Around 1 years	6-10 years
Session Length	6-15 min	16-30 min	6-15 min	6-15 min	16-30 min
Control Training games	AR, Coapt Control Companion AI games	computer games	N/A	N/A	N/A
Control training toys	Different sized objects	Age-appropriate toys	Switch-adapted toys	Variety of toys	Blocks, peg boards, cause and effect toys
Functional Training Frequency	two to three sessions/week	one session/week	one session/week	one session/week	variable frequency
Functional training tasks	dual hand tasks and exercises	hygiene, dual hand tasks, homework, baking	dual hand tasks	dual hand tasks	dual hand tasks, homework, personal care
Independent Training	One to five sessions, <5 min/session	One to five sessions, 1-5 min/session	One to five sessions, 1-5 min/session	Not included	Not included

6.2 Cross-case analysis

6.2.1 Demographic analysis

Across five participants, most were prosthetists (4 out of 5), and one was an OT (P5). In addition, participants demonstrated a wide range of clinical experience in pediatric myoelectric training, ranging from 4 to 30 years.

A pattern emerged regarding professional roles and involvement in training steps. All prosthetists (P1 to P4) reported being involved in signal training, whereas the OT (P5) reported not being involved in signal training. However, P2 explained additional roles during myoelectric training, including collaborating with an OT to determine optimal site selection and incorporating a range of age-appropriate activities. However, some inconsistencies were observed; P4, for example, had not been practicing pediatric myoelectric training for over 11 years and reported involvement only in signal training, yet answered questions related to game and functional training.

Figure 1

Participant's profession

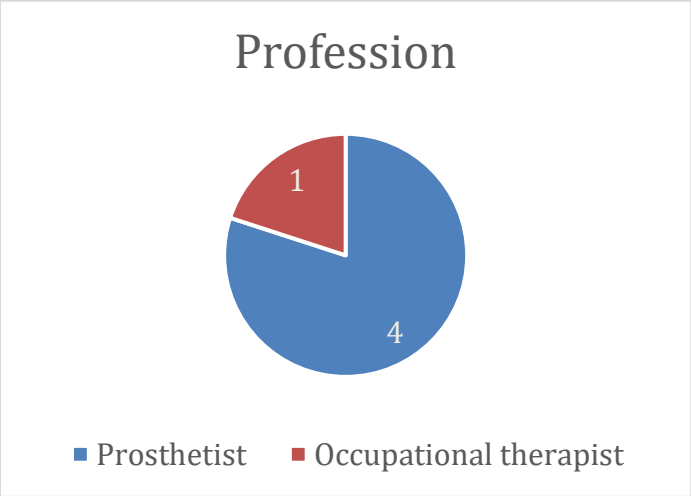


Figure 2.

Years of experience in myoelectric training

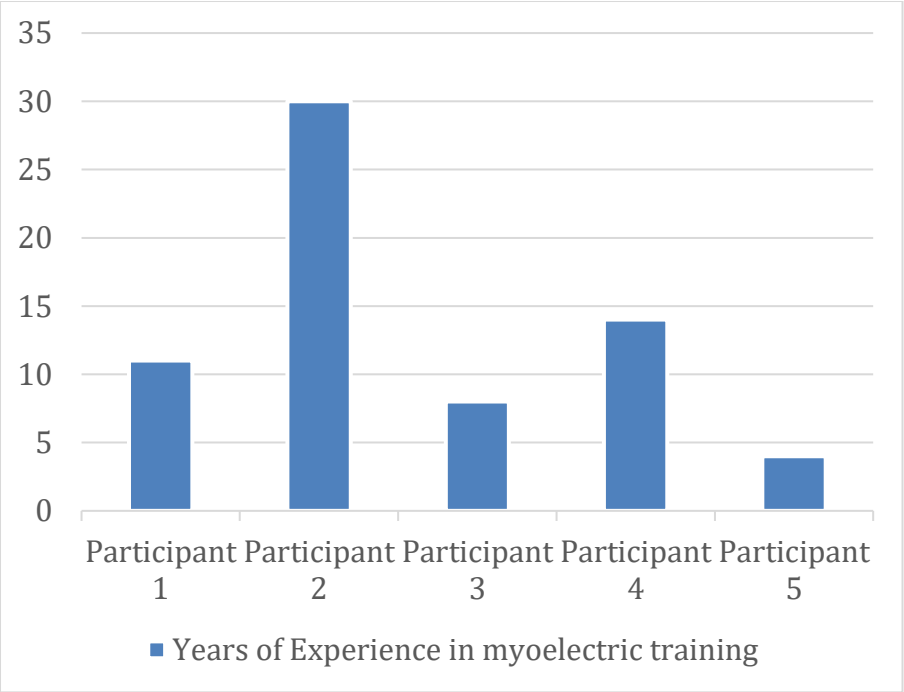
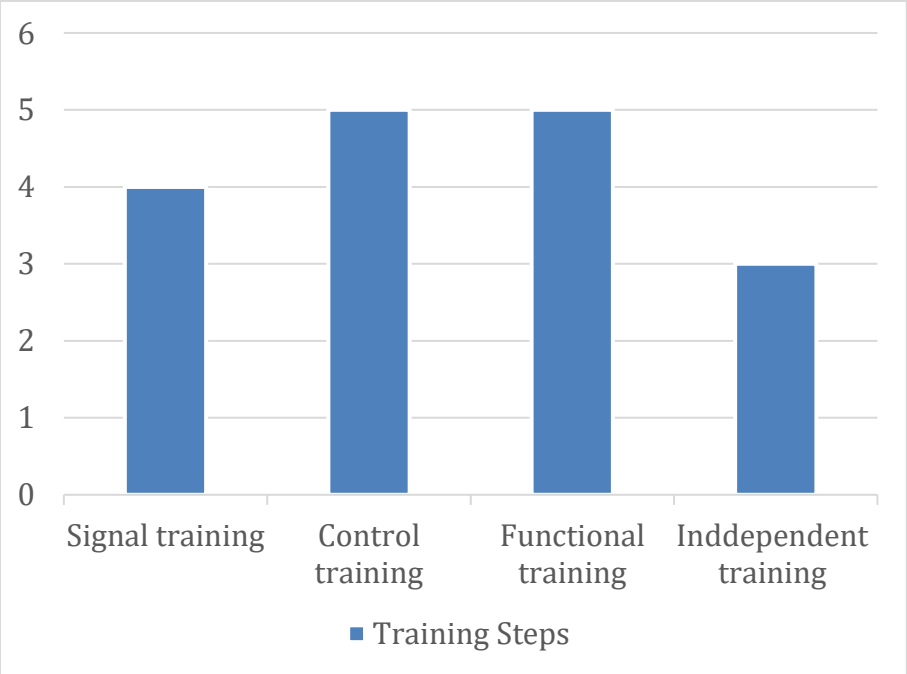


Figure 3.

Clinicians' involvement in training steps



6.2.2 Training approach

The participants' responses showed a lack of a standardized approach. A key finding across participants was the considerable variation in myoelectric training approaches, suggesting a lack of standardization in clinical practice. While there was some consistency in the sessions structure of individual participants, there was no unified approach in regarding sessions length, number of sessions, assessment of progress through training, and use of independent training. This might suggest that the current training approach is largely based on clinicians' experience and other factors, including family- and child-centred practice rather than using evidence-based guidelines. However, most participants agreed that myoelectric training is an innovative approach that leads to better outcomes in children, suggesting that they perceived myoelectric training as beneficial for progress in skill development and prosthesis use.

Participants varied in when myoelectric training was initiated for children with congenital limb differences, both in relation to prosthesis acquisition and in the age at which training began. Most participants also reported using a similar training approach for children with trans-radial and trans-humeral limb differences, although one participant described adapting the training plan based on amputation level and age.

Figure 4.

Time of training onset

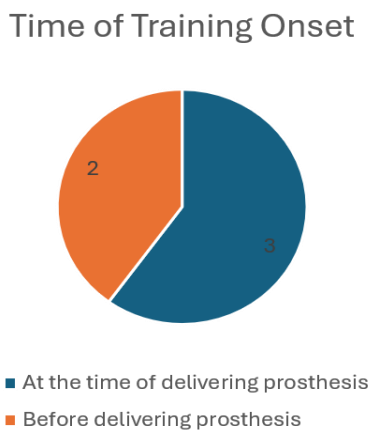


Figure 5.

Age of training initiation

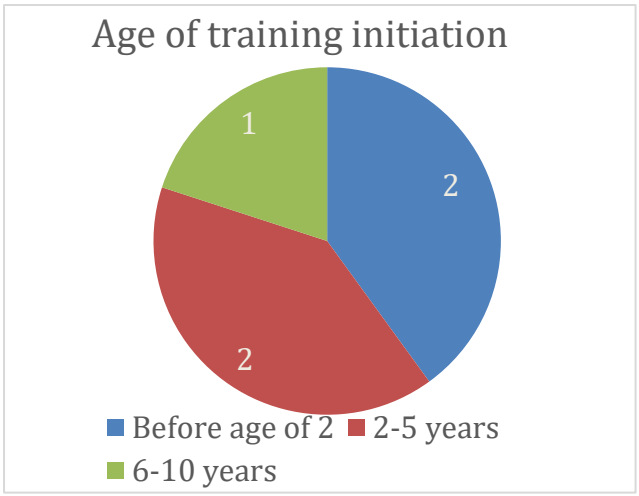


Figure 6.

Session length

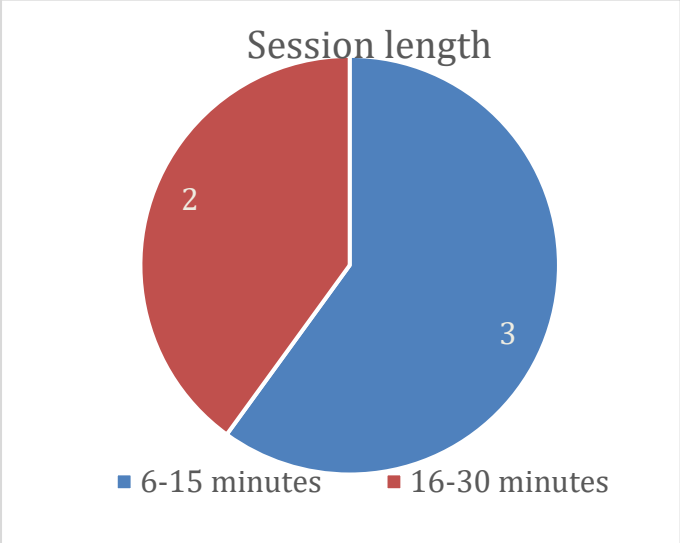
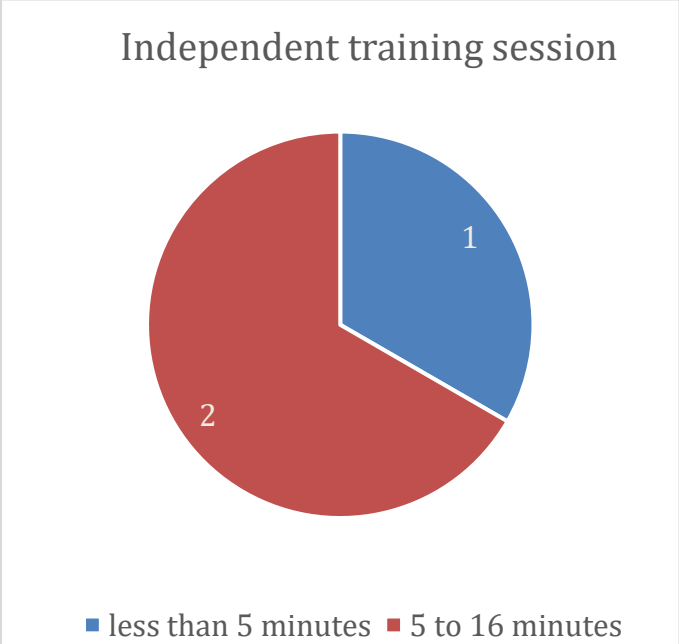


Figure 7.

Independent training length



6.2.3 Structure and delivery of training

The structure of training sessions varies across participants, specifically in duration and format. For signal training, most participants (P1, P3, P4) reported shorter sessions (6 to 15 minutes), while some (P2 and P5) reported longer sessions (16 to 30 minutes).

The length of control training sessions followed a similar trend, indicating consistency within clinicians' session structuring. One participant did not provide a specific duration, explaining that game training was integrated into play, and session length depended on the child's level of engagement. The duration of functional training sessions followed the same pattern across the participants.

The number of functional training sessions varied among the participants, reflecting flexible, individualized approaches rather than a standardized format. In most participants, training was delivered as a set number of sessions, while for some it was integrated into each visit or adjusted according to the family's interest and motivation to attend sessions and the child's needs. Overall, these findings suggest that the functional training structure was shaped by child- and family-centred considerations.

The frequency of functional training sessions followed the same pattern. Most participants had one functional training session per week; some reported having more sessions. The role of the family's location in determining the frequency of these sessions was highlighted by one participant.

A notable variation emerged in the use of training without a therapist. Most participants (P1, P2, P3) had integrated independent training sessions, with the same session number, but the training sessions' length varied.

Participants also described different strategies for assessing children's progress in independent training. Some used follow-up appointments, and some relied on family feedback.

Across participants, assessment during signal training was consistent. Most participants (P1, P2, P3, P4) reported evaluating muscle isolation and muscle co-contracture during signal training. However, one participant reported a more generalized approach focused only on eliciting EMG signals. Moreover, most clinicians (P1, P2, P3, P5) reported assessing all the muscle groups mentioned in the survey, including triceps, biceps, flexors and extensors during signal training.

6.2.4 Training activities and strategies

All participants reported using toys during control training, although the types of toys and selection strategies varied. Toy selection was guided by factors such as the child's age, interest, developmental level, and training goals, reflecting individualized and child-centred approaches. Some participants also incorporated technology-based tools, such as computer games, augmented reality, or virtual reality, to support engagement and prosthetic control training.

Functional training activities varied among participants. While dual-hand tasks were commonly used, some clinicians also incorporated exercises, hygiene, homework, baking, household chores, and personal care activities. These findings suggest that functional training was generally tailored to the child's age, daily routines and individual needs.

Most participants reported providing approximately one functional training session per week, although frequency varied depending on the child's needs, the clinician's approach, and practical factors such as geographic location. In addition, some participants incorporated independent training without a therapist, typically in brief sessions, indicating further variation in how training was structured and delivered.

Figure 8.

Functional training frequency

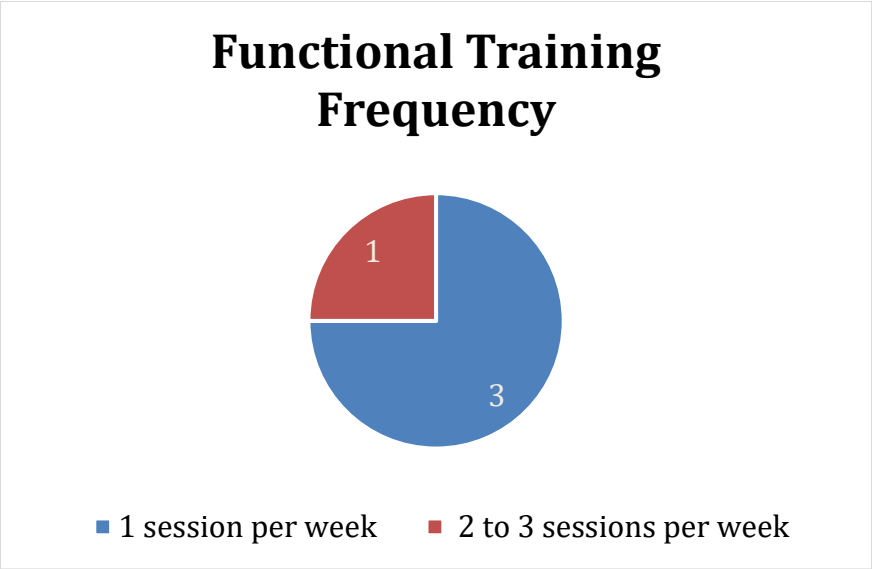


Figure 9.

Functional training tasks



6.2.5 Beliefs

Participants generally viewed myoelectric training positively, with most (P1, P2, P3, P4) strongly agreeing that it leads to better patient outcomes. However, perceptions of difficulty, complexity, and engagement varied considerably across participants. Most participants (P1, P2, P3, P4) believed that myoelectric training was an innovative approach that led to better patient outcomes. There were mixed views on whether myoelectric training

is easy for children to learn; some participants found it difficult, while others were neutral. However, most participants (P1, P2, P4) found prosthesis control easy. The child's cognitive ability, developmental stage, and early initiation of training influenced their varying perceptions, highlighting the child-centred training approach. Perceptions of signal training difficulty and complexity also varied. Most participants, (P1, P3, P5) found it as neither easy nor difficult. In addition, the prosthesis control was considered easy by most participants (P1, P3, P4).

Most participants found signal training engaging. In addition, participants highlighted the child-based nature of engagement and the importance of selecting motivating activities to enhance it. Greater variability was observed in participants' perceptions of control and functional training. While most participants found children engaged, views on difficulty and complexity differed.

There were varying perceptions about controlling a prosthesis in control training, and some (P3 and P5) perceived it as complex. In contrast, there was greater consistency in perceptions of engagement during control training. Most participants (P1, P2, P5) found the children to be engaged. Similarly, most participants observed the children to be engaged in functional training (P1, P2, P4, P5).

Participants had varying perceptions regarding the difficulty level of functional training. In addition, participants had various methods to increase enjoyment during functional training; they highlighted the clinician's role in creating enjoyable tasks by considering the child's interests and success in tasks, and by emphasizing the child-centred nature of training. Enjoyment in functional training depended on children's interest, success in tasks and children's engagement in them. In addition, the perceived role of the clinician in making the tasks enjoyable and fun varied.

Figure 10.

Prosthetic training difficulty

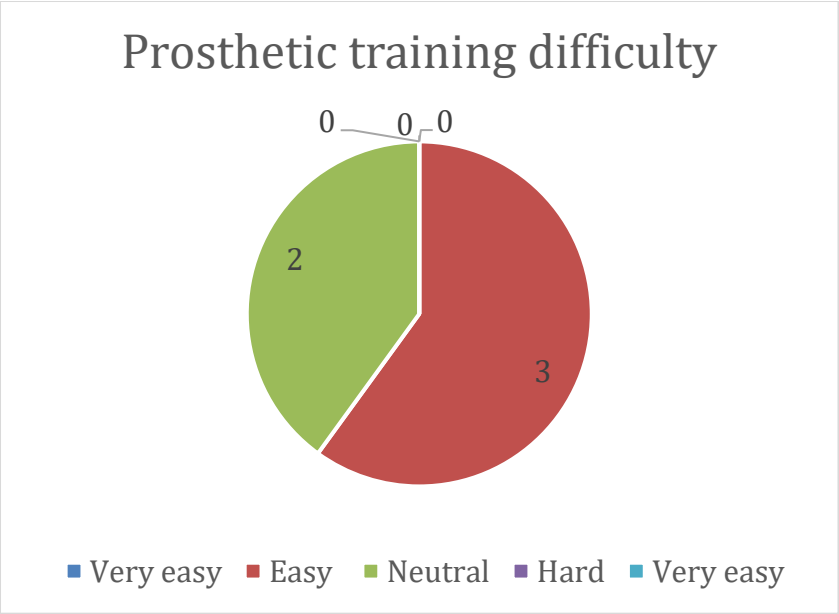


Figure 11.

Signal training difficulty

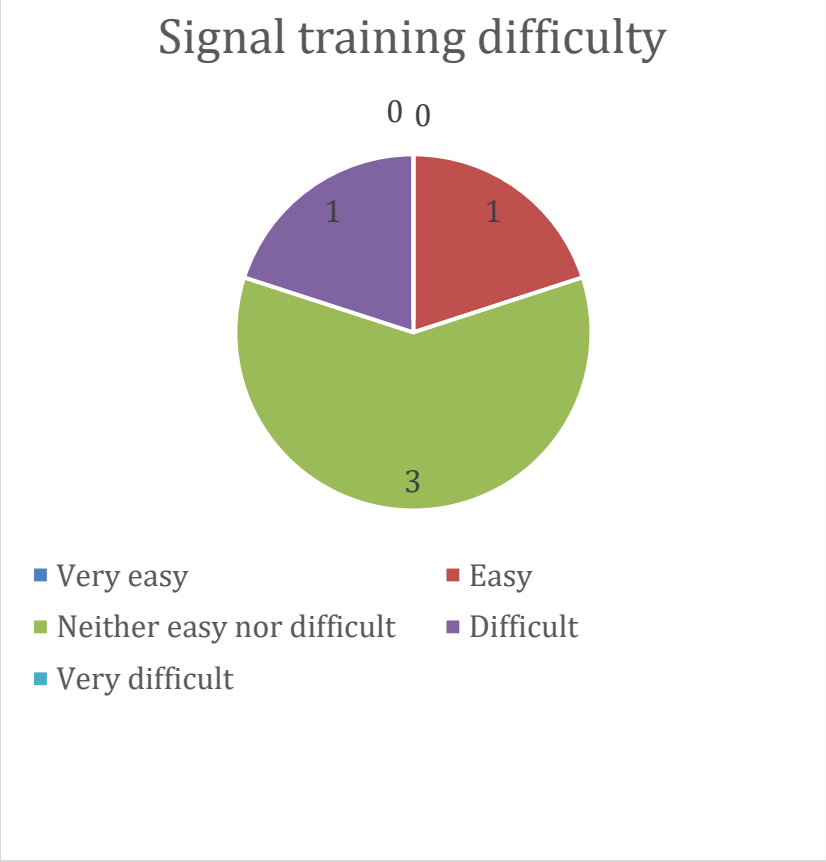


Figure 12.

Prosthetic control during training

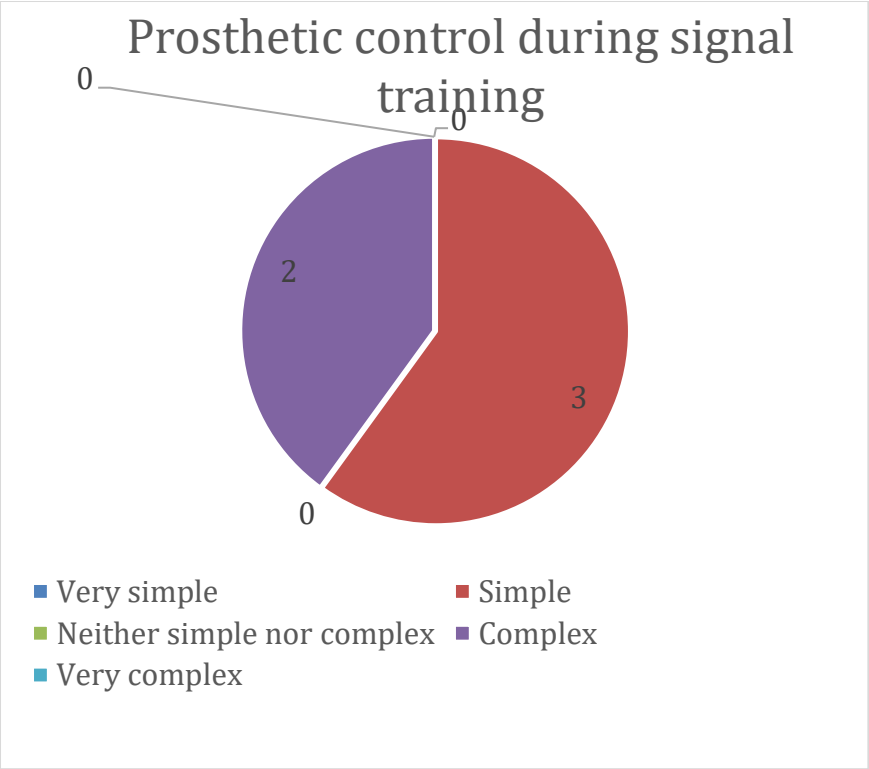


Figure 13.

Prosthetic control complexity during control training

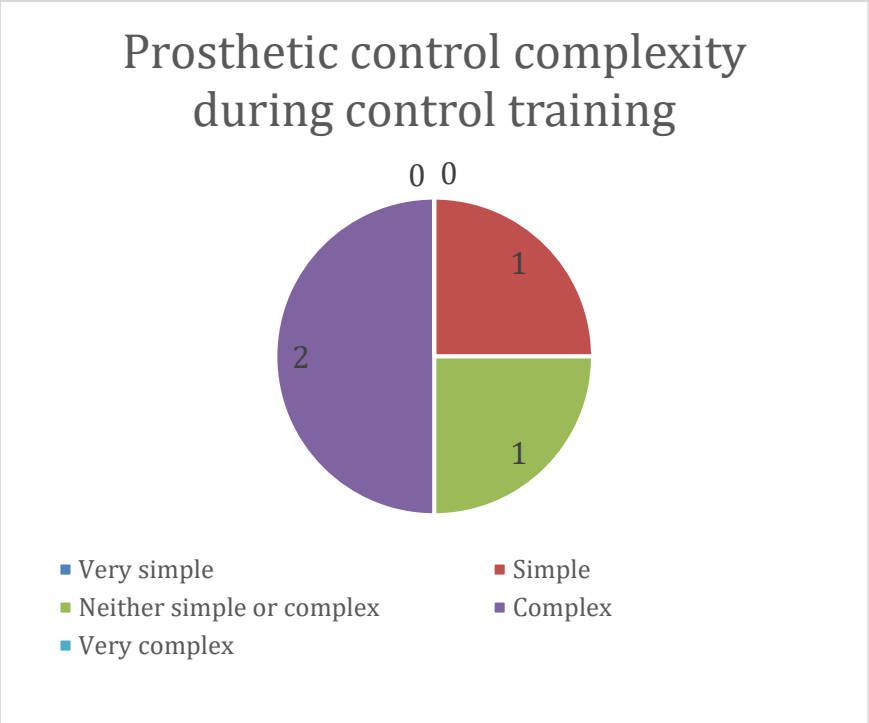


Figure 14.

Control training difficulty

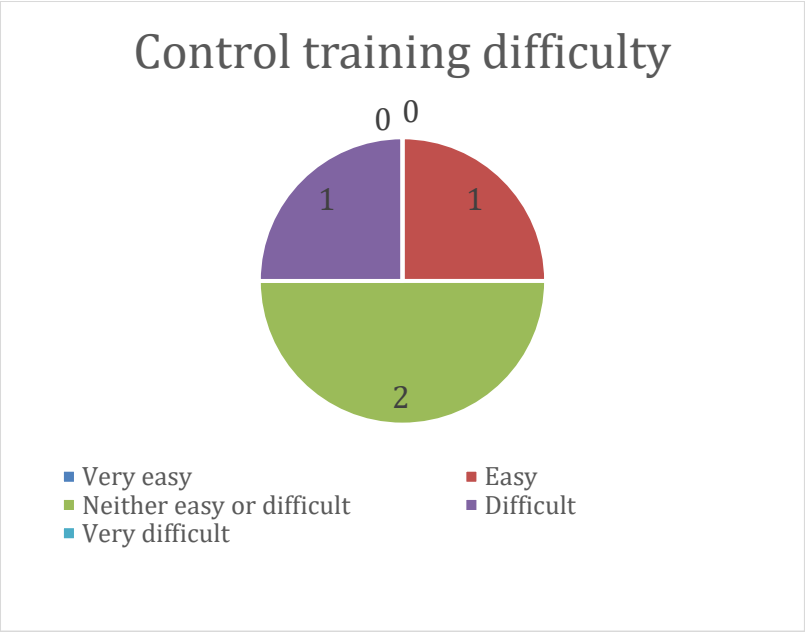


Figure 15.

Functional training difficulty



6.2.6 Clinical decision making

Participants described a range of approaches to assess children's readiness for myoelectric prosthesis use, with notable variation in the use of standardized or subjective

methods. Only one participant reported using standardized outcome measures, including Assessment of Capacity for Myoelectric Control (ACMC) and Prosthetic Upper Extremity Functional Index (PUFI). Subjective measures, such as consulting between the OT and the prosthetist, were mentioned by some participants.

Family involvement emerged as an important factor in participants' evaluation of children's readiness to receive a myoelectric prosthesis. Most participants (P1, P3, P5) reported consulting with the family as part of their assessment process. Family motivation in attending training sessions, prosthetics fitting, and family readiness to support training, child's cognitive ability, and goals and expectations influenced decision-making, highlighting the family-centred and child-centred training approach.

Functional readiness was assessed differently across participants. The child's previous prosthetic experience, cognitive ability to understand cause and effect, experience with an in-house myoelectric training unit, and ability to generate muscle activation in determining readiness were highlighted by participants.

6.2.7 Assessment measure to assess progress in training

There was a variation in progress assessment during signal training. The participants used various methods. Some participants evaluated progress through functional performance and timely task completion, while others assessed technical skills such as signal control, maintaining signal duration, and performing co-contraction. In contrast, one participant assessed progress by the amount of time spent and engagement during play.

6.3 Perceptions of the novel device

Some participants viewed the RCC device as a valuable addition to myoelectric training. They emphasized the value of real-time visual and auditory feedback, enabling children to observe the direct effects of their muscle contractions, creating a highly engaging

environment and highlighted the role of age-appropriate toys in promoting engagement. The potential of this device in the initial stages of myoelectric training and its customizability to the child's preference was highlighted by participants. In addition, participants suggested that the device could simplify training by allowing the therapist to focus on muscle contractions rather than on arm positioning, and that it could be used with switch-operated toys for younger children and with video games for older children. However, participants were unsure whether the device would be engaging for very young children (e.g., 1-year-old), although they saw the device's potential for older children.

Chapter 7: Discussion

7.1 Lack of a standardized approach

The cross-case analysis highlighted the lack of a standardized approach, indicating that the field is currently not guided by a shared evidence-informed framework. Instead, practice seems to be influenced by clinician experience, local resources, and child- and family-specific consideration. This may reflect the individualized nature of pediatric rehabilitation, but it can also create challenges for maintaining consistency in care, ensuring equitable access to training methods, and comparing outcomes across different settings.

The study's findings aligned with the literature, which lacked general guidelines for myoelectric training. Widehammar et al. (2020) conducted a scoping literature review and found few studies describing myoelectric training, with no single paper covering all training aspects and phases of training. Moreover, it was found that functional training and the integration of prosthetic training into activities of daily life were the least-described aspects of the myoelectric training process, further demonstrating the variability in guidance for pediatric myoelectric training.

It may be that there are variability and inconsistency in access to training resources, clinical experience, or support during pediatric myoelectric training among clinicians, as they had varying perceptions regarding receiving enough training. Development of future continuing education opportunities focused on aspects of training is warranted.

7.1.1 Myoelectric training structure

A unified approach to the structure of pediatric myoelectric training for children was seen across clinicians, starting with signal training, continuing with control training, and ending with functional training.

Consistent with our findings, the literature proposes a structured training approach. Hermansson (1991) presented a structured approach to training through the Skill Index

Ranking Scale (SIRS). SIRS uses a stepwise approach for developing prosthetic skills and documenting functional ability. This scale can be utilized to progress myoelectric training with a standardized approach. The clinician evaluates the child's current ability and progresses them gradually through the SIRS scale to train them with more difficult tasks. This is similar to what was reported in our study: participants start with signal training, then proceed to control training, and finally progress to functional training with more complex tasks, such as bimanual training. It has also been shown in the literature that training duration, structure and progress depend on many factors, such as amputation level or cognitive ability, and patient engagement (Johnson & Mansfield, 2014), which might explain the variation in our participants' responses.

Taken together, these findings suggest that a flexible structure where the clinician progresses from easy to difficult tasks and accounts for child-dependent factors is needed.

7.1.2 Independent training

A gap was found between evidence and practice regarding independent training. Independent training was not integrated into all the participants' training approaches; while some participants included independent training, there was a lack of consistency in the number of sessions, the length of sessions, and the evaluation of independent training.

This contradicts the current literature, which suggests that independent training is beneficial. For instance, Lukaszek et al. (2022) reported that their 8-week home intervention program led to significant improvements in functional performance and independence among children with ULD, as evidenced by significant increases in Prosthesis Measurement of Independent Function (PMIF) scores, and decreased (more efficient) task completion time. These suggest that home training can improve functional performance among children. In addition, the results highlight the need for structured, independent training protocols that provide clinicians and families with guidance on training frequency, duration, and evaluation.

Integrating standardized home-based training resources may enhance consistency in practice and improve functional outcomes for children with upper limb differences (ULD). However, clinicians might not be aware of the benefits of providing a structured independent home training program.

7.1.3 *Assessment measures to determine readiness to receive a myoelectric prosthesis*

The use of standardized assessment tools was limited, potentially leading to inconsistent care. Clinicians' experience and training may strongly influence clinical decision-making in assessing the readiness of the child to receive a myoelectric prosthesis. For instance, most of our participants emphasized the use of subjective measures to evaluate a child's readiness to receive a prosthesis, including their developmental stage (age), functional outcomes, and family reports. And only one participant used standardized assessment tools, including Assessment of Capacity for Myoelectric Control (ACMC) and the Prosthetic Upper Extremity Functional Index (PUFI).

Buffart et al. (2006) explored assessment tools for evaluating upper-limb function in children with congenital ULD. These tools not only measured performance but also assessed activity, including the child's capacity and performance in activities of daily life, and are child-centred, and engaging for the child. The authors recommended using the Assisting Hand Assessment (AHA), a play-based assessment tool.

Similarly, play-based assessments were highlighted by one of our participants, as they perceived that they disguised the assessment as play. Play-based assessments have shown promise in the literature; for instance, Cordray et al. (2025) evaluated game-based assessments for children with ULD. Cordray et al. (2025) highlighted that these approaches make assessment more child-friendly and support more accurate performance. Cordray et al. (2025) also recommended using the AHA for play-based assessments, with a focus on age-

appropriate tasks. These authors highlighted that using these approaches make assessment more child friendly and support more accurate performance.

In addition, one participant used the Prosthetic Upper Extremity Functional Index (PUFI) questionnaires, which are parent-reported. The Prosthetic Upper Extremity Functional Index (PUFI) is a questionnaire developed to assess how frequently children use their prosthesis during daily activities. The questionnaire collects information from both parents and children regarding the performance of bimanual tasks with and without the prosthesis, as well as their perceived usefulness of the prosthetic device. Higher scores represent greater functional use of the prosthesis, whereas lower scores indicate less frequent use and reduced perceived benefit (Wright et al., 2001).

Consequently, combining both child-centred, play-based assessment tools and family-based questionnaires might help standardize readiness assessment. Our study's findings show a lack of use these tools possibly indicating a gap between evidence and current clinical approaches.

7.2 Child-centred approach

Incorporating a strong child-centred, play-based approach was evident across all participants. All clinicians reported using toys during control training, suggesting a shared emphasis on play as a primary method of engagement. Toy selection was guided by factors such as the child's age, developmental stage, and personal interests, reflecting an individualized and developmentally appropriate approach. Clinicians adapted training to increase engagement and to support children's developmental stages. For instance, they used a variety of toys, computer games, AR, and VR.

7.2.1 Play-based approach

There was an emphasis on age-appropriate and individualized play across all participants, which might be explained through Piaget's (1952) developmental theory. Piaget's theory indicates that children learn differently from adults, depending on their developmental stage. Younger children, before the age of two, might benefit from sensory exploration, movement and trial-and-error interactions through repetition and immediate feedback. After the age of 2, children engage in play-based tasks due to symbolic thinking, imagination, and pretend play. As children get older, they might benefit from structured functional tasks, goal-oriented activities, and independent training as they develop logical thinking. These findings highlight the importance of adapting myoelectric training practices to the child's developmental stage. However, not all children reach developmental stages at the same age, highlighting that the tasks should be individualized to each child's cognitive abilities (Piaget, 1952; Wilks et al., 2020).

In addition, the development of prosthesis control skills needs repetitive motor practice and sensory feedback to support motor learning. However, repetitive tasks might reduce a child's engagement and motivation during training. As a result, clinicians might include play-based control training to maintain attention and engage children in these repetitive tasks. Previous literature has highlighted the importance of maintaining engagement among children, as they may lose interest and focus when training becomes repetitive and potentially boring (Hashim et al., 2021; Shimokakimoto et al., 2020).

7.2.2 Engagement

Engagement was identified as a central factor influencing training effectiveness. Rather than being a stable feature of any one stage of training, engagement seems to depend on how well activities align with the child's interests, developmental level, motivation, and opportunities for success. In addition, technology-assisted training emerged as an additional

strategy to enhance engagement. Participants reported using computer games, augmented reality systems, and other digital tools that provide real-time visual and auditory biofeedback. These tools allow children to observe the effects of their muscle contractions, potentially supporting motor learning and engagement.

The findings of the present study align with previous literature suggesting that game-based rehabilitation can enhance motivation and engagement during myoelectric training. Hashim et al. (2021) reported that video game-based rehabilitation increased participant interest, motivation, and adherence while also improving muscle coordination and strength. Previous research suggests that incorporating playful elements into rehabilitation can improve patient engagement and persistence during training (Hubbard et al., 1985; Prahm et al., 2018).

The interest in integrating technologies such as virtual reality suggests a growing trend toward incorporating immersive and interactive tools into myoelectric training. Previous literature also highlighted the role of VR in supporting training for children, as it provides an immersive environment for them to practice controlling a myoelectric prosthesis even before receiving the device (Prahm et al., 2017). However, evidence regarding the transfer of these skills to actual prosthetic use is mixed. For instance, Maas et al. (2025) found improvements in training performance and switch control timing. However, improvements were also observed in control groups, suggesting possible testing effects rather than clear transfer effects. The authors highlighted substantial individual differences in learning, emphasizing the need for individualized and developmentally appropriate pediatric training approaches. Similarly, van Dijk et al. (2016) suggested that transfer to real prosthetic use depends on the similarity between the training activity and functional prosthetic tasks, emphasizing the importance of task-oriented and goal-directed training approaches.

7.2.3 Functional training and early training

Bimanual training is important for motor development, and all participants incorporated this into their functional training. Previous literature highlights that active use of both upper limbs is important for developing bimanual function and neuronal connections, and bimanual tasks during training may support sensorimotor development and integration of the prosthesis into daily activities (Peterson & Prigge, 2020).

7.3 Family-centred care

Despite not including parents in this study, all participants highlighted family involvement as an important aspect of the rehabilitation plan, influencing assessment, training, and the ongoing use of the prosthesis. These findings also support the use of family-centred rehabilitation approaches. Krebs et al. (1991) emphasized that parents should be actively involved in treatment sessions and home programs to support prosthetic use and wearing tolerance. It is important to collaborate with and educate families in training and incorporate strategies that support and enhance family engagement. Families are active partners in children's training as they contribute to supporting and reinforcing training activities at home, potentially improving training experience and promoting long-term prosthesis use.

In addition, participants consulted with families and highlighted the role of family motivation and engagement in decision-making. These findings align with previous literature emphasizing the important role of family involvement in pediatric prosthetic rehabilitation, including Kanas (2014), who reported that parents often have specific expectations and goals for their child's prosthetic intervention. Early clinical appointments involve clear communication, education about treatment options and rehabilitation approaches, introduction to the interdisciplinary rehabilitation team, and collaborative treatment planning.

Successful training may depend not only on the child's abilities but also on the family's readiness, and capacity to support ongoing participation in rehabilitation. For instance, participants noted that family motivation and willingness to attend sessions influenced the structure, frequency, and intensity of training. In addition, the functional training was influenced by family location, family interest, engagement, and availability. For instance, one participant included parents in play sessions.

Previous literature has similarly emphasized the important role of parents in successful prosthetic training. Hermansson et al. (1991) highlighted that parental support is essential, as parents help children manage the day-to-day demands of prosthetic use and support them throughout the process of trial-and-error learning. The authors also emphasized the importance of close collaboration between occupational therapists and parents during rehabilitation. These findings may indicate that family involvement influences not only emotional support and adherence to training but also the consistency and continuity of practice within the child's everyday environment.

Independent training is often performed under parental supervision. For example, one participant mentioned that family feedback is used to evaluate the child's progress during home training. These findings align with previous literature. Lukaszek et al. (2022) described home programs and interventions as activities completed by the child under parental guidance within the child's home environment. Such approaches allow for structured practice in a natural and familiar setting and may support successful learning, functional skill development, and meaningful generalization of intervention activities to daily life.

7.4 Interprofessional approach

7.4.1 Division of, and collaboration within, professional roles

Pediatric myoelectric training involves both role specialization and interdisciplinary collaboration, which may enhance continuity of care and support individualized

rehabilitation. For example, participants showed a division of responsibilities between the occupational therapist and the prosthetist, with each clinician contributing based on their clinical expertise and background while working toward the same goal with the client.

Different professional roles were involved in different stages of pediatric myoelectric training. The occupational therapist was mainly involved in control and functional training, while all prosthetists were involved in signal training.

These findings align with previous literature emphasizing the importance of interdisciplinary collaboration in pediatric prosthetic training. Previous literature (Johnson & Mansfield, 2014) emphasizes that successful prosthetic rehabilitation requires close collaboration between occupational therapists and prosthetists. Occupational therapists support children in learning to use a prosthesis during activities of daily living and integrating it into everyday life, while prosthetists provide expertise regarding prosthetic components, technology, fitting, and programming. The literature also highlights the importance of ongoing communication and shared understanding among professionals, when possible, including attending each other's appointments, to improve coordinated care and better support the child's rehabilitation goals. Furthermore, occupational therapists often spend the most time with children during prosthetic training, reinforcing education and skills introduced during prosthetic fitting and delivery (Johnson & Mansfield, 2014).

In addition, the occupational therapist and prosthetist frequently collaborate and consult each other during decision-making, specifically to assess children's readiness to receive a prosthesis. For example, one prosthetist described collaborating with the occupational therapist during site selection and development of age-appropriate training activities.

The collaborative approach observed in our study may help ensure that decisions regarding myoelectric prosthetic training consider multiple factors, including physical

readiness, developmental level, functional goals, and family perspectives. This may contribute to more individualized and child-centred rehabilitation planning. This finding is supported by prior literature (Kanas, 2014; Benjamin, 2021) that describes pediatric rehabilitation for children with upper limb differences as an interdisciplinary process. The literature suggests that children with ULD benefit from coordinated care involving physicians, occupational therapists, physical therapists, social workers, prosthetists, children and their families. In this system, team members collaborate to identify the child's goals and needs related to development, activities of daily living, mobility, education, recreation, and social participation (Kanas, 2014; Benjamin, 2021).

Overall, these findings highlight the importance of a coordinated, team-based approach in pediatric myoelectric rehabilitation. Although clinicians may have distinct professional responsibilities, ongoing collaboration and shared decision-making appear to play an important role in supporting individualized, developmentally appropriate training.

7.5 Perceptions of the novel device

7.5.1 Perceptions of the novel device usefulness

Perceptions the novel training device usefulness were generally positive, with clinicians highlighting its potential to enhance engagement through real-time feedback and customizable activities. Most participants believed the device could be useful during myoelectric training, particularly in early stages such as signal training. Clinicians emphasized that the device could help children understand cause-and-effect relationships, as muscle contractions produced immediate visual or auditory feedback via toy activation. These findings align with previous literature on feedback-based pediatric prosthetic training systems. Shimokakimoto et al. (2020) highlighted that interactive feedback during therapeutic play activities helped sustain children's attention and engagement during repetitive training

exercises and suggested that play-based biofeedback systems may enhance motivation and participation in pediatric prosthetic rehabilitation.

Participants also suggested that the device could support individualized and developmentally appropriate training. For younger children, switch-adapted toys and simple cause-and-effect activities were suggested, while for older children, computer games and more advanced interactive activities were proposed. These findings reflect the developmental progression of myoelectric training, which depends on the child's developmental readiness, communication skills, and ability to understand control instructions as described in previous literature (Peterson & Prigge, 2020). Some clinicians questioned whether co-contraction control would be appropriate for very young children, as single-site activation is more commonly used during the early stages of training. Younger children may benefit more from simplified single-signal activities during pre-prosthetic or early signal training stages, whereas older children may be better able to use dual-site or co-contraction-based activities.

7.5.2 Perceptions of the novel device's engagement

Participants further suggested that the device may increase engagement during repetitive training tasks. Since myoelectric training often requires repetitive practice to support motor learning and neuroplasticity, engaging and meaningful activities may help sustain participation over time.

Sensory feedback may contribute to embodiment and agency during prosthetic training. van den Heilgenberg et al. (2018) suggested that repeated prosthesis use may contribute to neuroplasticity and prosthetic embodiment through increased visuomotor integration and the incorporation of the prosthesis into body representation. Embodiment literature emphasizes the importance of visual, auditory, tactile, and motor feedback in supporting the integration of a prosthesis into body representation. Therefore, by pairing muscle activation with interactive sensory feedback and meaningful play activities, the

proposed device may potentially support engagement, motor learning, neuroplasticity, and long-term prosthesis use (Eftekari et al., 2023).

Chapter 8: Conclusion

The purpose of this study was to explore clinicians' perceptions, attitudes, and experiences of myoelectric training in children and to gaining insight into children's engagement, prosthesis use, and overall training experiences. In addition, this study aimed to gather clinician feedback on the novel RCC device and its potential to enhance myoelectric training, specifically regarding engagement, usefulness, and application in pre-prosthetic training.

The findings of this study highlighted a lack of standardized approaches in pediatric myoelectric training. However, clinicians consistently emphasized play-based, developmentally appropriate, family-centred, and interdisciplinary approaches to training. These findings suggest the importance of developing more standardized training protocols, assessment methods, and outcome measures to support progress across different training stages while maintaining an individualized and child-centred approach.

The emphasis on play- and toy-based tasks aligns with developmental theory and highlights the importance of using age-appropriate, engaging activities to maintain children's engagement and motivation during training. In addition, integrating game-based approaches and interactive technologies might enhance engagement in pediatric myoelectric rehabilitation. Moreover, integrating independent training sessions could enhance training outcomes. The findings also highlight the importance of interdisciplinary collaboration, as prosthetists contribute technical expertise while occupational therapists contribute knowledge about developmental stages and age-appropriate functional activities.

The limited availability of structured training resources may suggest a need to develop evidence-informed guidelines, materials, and resources to support clinicians in implementing engaging and effective pediatric myoelectric training approaches.

8.1 Strength and limitations

A strength of this study was the national representation of clinicians across Canada. Participants represented both the public and private sectors and were recruited from Alberta, Ontario, and Manitoba, providing perspectives from multiple clinical settings and provinces.

Some limitations are recognized in the current study. The small number of participants and representation of only prosthetists and one occupational therapist may have affected the transferability and representativeness of the findings. Other healthcare professionals involved in pediatric myoelectric rehabilitation, such as physiotherapists or rehabilitation engineers, were not represented in the sample.

Additionally, the study was based on clinicians' self-reported perspectives, which may have been influenced by recall bias. For example, one participant had not been involved in pediatric myoelectric training for approximately 11 years, and their responses may not fully reflect current clinical practices and training approaches.

Recruitment was challenging due to the small population of clinicians involved in pediatric myoelectric rehabilitation. Recruitment efforts included contacting organizations such as the War Amps, Orthotics Prosthetics Canada (OPC), the Canadian Association of Occupational Therapists (CAOT), and the Canadian Physiotherapy Association. Study flyers were distributed through OPC and CAOT; individual CAOT members were contacted; and snowball sampling was used to reach potential participants. The Canadian Physiotherapy Association and War Amps declined to share the flyer. One potential contributing factor to the small sample size might have been the inclusion criterion requiring at least two years of experience in pediatric myoelectric rehabilitation.

Chapter 9: Future research

This study focused only on clinicians' perspectives and did not explore the experiences of children with upper limb differences or their families. We initially intended to include parents of children with upper limb differences across Manitoba; however, recruitment challenges prevented this aspect of the study. Future research may benefit from including children and families to better understand their goals, expectations, engagement, and lived experiences with myoelectric training and prosthesis use.

Given the relatively low prevalence of children with upper limb differences, future studies might benefit from longitudinal case study designs to evaluate the effectiveness and clinical application of the novel RCC device across different stages of training, particularity during pre-prosthetic and signal training. Future research could also explore the device's potential for independent home-based training and its use with different age groups and different tasks.

Finally, future studies may benefit from the development or use of standardized assessment measures to evaluate readiness for myoelectric prosthesis use and progress during training. Further research may also explore how structured training approaches can be balanced with child-centred, family-centred and play-based training.

Chapter 10: Knowledge Translation Plan

Our knowledge translation plan aims to effectively disseminate the results of our study to a diverse group of stakeholders, including clinicians (occupational therapists, physical Therapists, prosthetists, and rehabilitation engineers), parents, and children with upper limb differences. We will use multiple channels to ensure broad reach and meaningful engagement with our target audience.

The SSCY family network newsletter will be used for sharing key findings. By publishing an article accompanied by visual aids such as graphs and infographics, the newsletter will present the study's outcomes and their implications for practice and patient care in a clear and accessible manner. This approach ensures that both clinicians and families within the SSCY network can easily digest and apply the information. In addition, we will present at breakfast at SSCY.

A detailed post on the ENRRICH blog will expand our dissemination efforts to a broader audience, including clinicians, researchers, and families interested in pediatric rehabilitation. This blog post will provide insights into the study's methodology, results, and practical applications. In addition, a summary of the results will be sent to OPCanada.

The results of the study will be presented as a poster at the 2026 Orthotics, Prosthetics & Rehabilitation Conference, and 2026 held in Montreal, Quebec, and at the 2026 Manitoba Student Health Research Forum poster competition.

By employing these comprehensive and varied dissemination channels, our knowledge translation plan will effectively reach and impact all relevant stakeholders, enhancing the implementation and application of the research findings in clinical practice and patient care.

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Appendix

Appendix: Clinicians' questionnaire

Evaluating attitudes, perceptions, and experiences of parents, and clinicians regarding myoelectric training process, University of Manitoba

Thank you for accessing the parents' questionnaire to explore attitudes, perceptions, and experiences of myoelectric training. Reyhane Aliakbari, a Master of Rehabilitation Sciences student at the University of Manitoba, is conducting this study.

You were selected to participate in this study because of your experience with myoelectric training. This survey is being conducted to evaluate your experiences as a clinician working in myoelectric field. Finally, we want to present a new training device designed by the Rehabilitation Centre for Children, Winnipeg, Manitoba and ask for your initial thoughts and feedback.

Your responses will be collected through an online survey and take about 15 minutes to complete.

Your participation in this on-line survey is completely voluntary.

You do not have to answer any questions you do not want to.

This questionnaire is anonymous, and we will not gather any personal information including tracking your IP, name, address, phone number or any other personal information with your responses.

This survey is conducted through the REDCap survey host at the University of Manitoba. The paper copy of the data will be stored in a secure filing cabinet in a locked

office located in the Epic Lab, RR367-800 Sherbrook Street, Health Sciences Centre Hospital, Winnipeg, Manitoba, Canada. All the data will be stored in the share point account of the University of Manitoba, and access is restricted to researchers in the project who have undergone PHIA training. The gathered virtual data will also be placed in the secure research environment, the REDCap web-survey host. The original data files will be stored in the um secured servers through the University of Manitoba.

If you are interested in your survey results, we will ask for your email address at the end of data collection via a separate survey link. If you choose, you can be entered to win a 50-dollar gift card. To be part of this draw, a separate survey link will collect participants email address to be included in the draw. Your email will be collected separately from the survey data to maintain data anonymity.

Please note that once you submit your survey responses you will NOT be able to withdraw them as we cannot link the survey responses back to you. Your chance of winning depends on the number participating and the draw will be done within one week of the survey being closed.

There are no risks in completing this survey. Information gathered in this research study will be published or presented in public forums in an aggregated and anonymized fashion. This data may be shared with other researchers in the future to help answer research questions in this area.

Your participation is important to us and will help us to improve myoelectric training in the future, possibly helping the other children who will go through myoelectric training in the future.

If you have any questions about this survey study, please do not hesitate to contact Reyhane Aliakbari, master's student at or her supervisor, Dr. Jacquie Ripat at

This study has been approved by the University of Manitoba Health Research Ethics Board.

I consent to participate in this survey. ○ Yes ○ No

Demographic questions

1. How many years of experience do you have with the myoelectric training process with children?

2. What is your role in myoelectric training?

    1) Occupational Therapist

    2) Prosthetist

    3) Rehabilitation engineer

    4) Physical Therapist

    5) Other

3. Can you describe the role you have in myoelectric training process?

4. What steps of myoelectric training are you engaged in?

    1) Signal training

    2) Myoelectric training with games or toys

    3) Training with activities of daily living

4) Other

5. If you selected the other response option, please explain.

6. Usually, when do you start myoelectric training with children?

1) Before acquiring the prosthesis

2) At the same time of acquiring the prosthesis

3) After acquiring the prosthesis

4) Other

7. Can you describe when you start myoelectric training with children? (If they selected other response option in the 6th question)

8. I have received sufficient training and education on how to conduct myoelectric training sessions.

1) Strongly agree

2) Neither agree or disagree

3) Disagree

4) Strongly disagree

9. Myoelectric training is an innovative approach that can lead to better patient outcomes.

1) Strongly agree

2) Neither agree or disagree

3) Disagree

4) Strongly disagree

10. In my opinion, myoelectric training is easy to learn for children.

1) Strongly agree

2) Neither agree nor disagree

3) Disagree

4) Strongly disagree

Myoelectric training process for congenital limb differences

11. In the case of congenital limb differences, on average, how old are the children when they first start myoelectric training?

1) Younger than 2 years old☐

2) Between 2 to 5 years old☐

3) Between 6 to 10 years old☐

4) older than 10 years of age☐

12. Do you have different training plans for children with trans-radial and trans-humeral upper limb differences? Yes☐ No☐

13. Does the training plan start at the same age for children with both trans-radial and trans-humeral limb differences? Yes☐ No☐ (if the answer to 12th question was yes)

14. At what age do you start myoelectric training for children with a trans-radial limb difference? (If the answer to 13th question was yes)

15. At what age do you start myoelectric training for children with trans-humeral limb difference? (If the answer to 13th question was yes)

Myoelectric prosthesis assessment

16. What assessment scale or measure do you use to evaluate a child's readiness to receive a myoelectric prosthesis?

17. What skills do you assess to evaluate a child's readiness to receive a myoelectric prosthesis?

Perceptions regarding myoelectric training

18. How do you perceive the difficulty level of myoelectric training for children?

1) Very Easy
2) Easy
3) Neither easy nor hard
4) Hard
5) Very hard

19. How do you perceive the complexity of controlling a prosthesis for children during training?

1) Very Easy

2) Easy

3) Neither easy nor hard

4) Hard

5) Very hard

Signal training

20. What software and hardware do you use during signal training?

21. What do you assess during signal training sessions?

1) Muscle isolation

2) Muscle co-contracture

3) Other

22. Can you explain what you assess during signal training sessions? (If the answer to above question is 3)

23. What muscles do you assess during signal training sessions?

1) Triceps

2) Biceps

3) Flexors

4) Extensors

5) Other

24. What muscles do you use during signal training sessions?

25. On average, how long are signal training sessions?

1) Less than 5 minutes

2) Between 6 and 15 minutes

3) Between 16 and 30 minutes

4) more than 30 minutes

26. How do you assess children's progress in signal training?

27. How difficult is myoelectric training for children?

1) Very Easy

2) Easy

3) Neither easy nor difficult

4) Difficult

5) Very difficult

28. How complex is prosthesis control for children during signal training?

1) Very simple

2) simple

3) Neither simple nor complex

4) Complex

5) Very complex

29. How do you perceive the children's engagement in game training for signal training?

1) Very engaged

2) Engaged

3) Neither engaged nor disengaged

4) Disengaged

5) Very disengaged

30. Do you have any additional comments regarding signal training?

Games and systems used in myoelectric training

31. Which game methods do you use in myoelectric training?

1)Toys

2) Virtual reality

3) Augmented reality

4) Computer games

5) Other

32. Please explain (If the answer to above question was 5)

33. Which toys do you use during training sessions? (If the answer to above question was toys)

34. Which game(s) do you use during training sessions? (If the answer to above question was 2, 3, or 4)

35. On average, how long are your game training sessions?

1) Less than 5 minutes

2) Between 6 and 15 minutes

3) Between 16 and 30 minutes

4) More than 30 minutes

36. How do you perceive the difficulty level of myoelectric training for children?

1) Very Easy

2) Easy

3) Neither easy nor difficult

4) Difficult

5) Very difficult

37. How do you perceive the complexity of controlling prosthesis for children during training?

1) Very simple

2) simple

3) Neither simple nor complex

4) Complex

5) Very complex

38. How do you perceive the children's engagement in game training?

1) Very engaged

2) Engaged

3) Neither engaged nor disengaged

4) Disengaged

5) Very disengaged

39. Do you have any additional comments regarding games and systems used in myoelectric training?

Functional step of myoelectric training

40. How long are the functional training sessions?

1) Less than 5 minutes

2) Between 6 and 15 minutes

3) Between 16 and 30 minutes

4) More than 30 minutes

41. How many sessions does functional training generally include?

42. What is the weekly frequency of functional training sessions?

1) Once

2) Two to three sessions

3) Four to five sessions

4) More than five sessions a week

5) Other

43. How many functional training sessions are included in a week? (If the selected the other response option for above question)

44. How do you perceive the children's engagement in functional training?

1) Very engaged

2) Engaged

3) Neither engaged nor disengaged

4) Disengaged

5) Very disengaged

45. How do you perceive the difficulty level of functional training for children?

1) Very simple

2) simple

3) Neither simple nor complex

4) Complex

5) Very complex

46. How do you perceive the complexity of controlling a prosthesis for children during their functional training?

1) Very simple

2) Simple

3) Neither simple nor complex

4) Complex

5) Very complex

47. Please comment on the level of enjoyment children have during functional training,

48. What tasks you address during functional training?

1) Hygiene

2) Dual-hand tasks

3) Homework

4) Exercise

5) Other

49. If other, please explain the tasks you address during training sessions.

50. Do you have any additional comments about functional myoelectric training?

Myoelectric training without a therapist

51. Does your training plan include training sessions without your attendance? (For example, in home training sessions) Yes☐ No☐

52. On average, how many training sessions, without your attendance, does your myoelectric training process include?

1) 1 to 5 sessions☐
2) 6 to 10 sessions☐
3) 11 to 20 sessions☐
4) More than 20 sessions☐

53. How do you assess children's performance during these training sessions?

54. How do you assess children's progress during these training sessions?

55. How do you perceive children's engagement with these training sessions?

1) High engagement☐
2) Medium engagement☐
3) Low engagement☐
4) No engagement☐

In this video you will be introduced to a new device which will be used in myoelectric training process.

56. Do you think that this device will be useful in the myoelectric training process? Yes☐ No☐

57. Why do you think this device will be useful in the myoelectric training process? (If the response to 56 question was yes).

58. Why do you think this device will not be useful in the myoelectric training process? (If the response to 56 question was no)

59. Do you think that this device will make the myoelectric training sessions more engaging? Yes☐ No☐

60. Can you explain why this device would improve myoelectric training engagement? (If the response to question 59 was yes).

61. Can you explain why you believe that this device will not make the training process more engaging? (If the response to question 59 was no).

62. Do you have any additional comments regarding this new device?