

OCCUPATIONAL THERAPY: TRAINING POSTURAL CONTROL FOR FUNCTIONAL UPPER LIMB PROSTHESIS USE

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INTRODUCTION

Healthcare professionals working with upper limb (UL) amputees more often than not, have the privilege of working with a generally healthy patient population. Traumatic loss of the upper limb in previously active and productive persons does not remove their intrinsic motivation for active participation in life. As they recover from the abrupt change in their functional status, this innate drive may be somewhat diminished for a time. However, with a supportive environment for recovery, it is possible to return to a healthy and productive lifestyle. It is incumbent upon rehabilitation professionals to create optimal conditions for patient success. Meeting this challenge requires the coordinated efforts of a rehabilitation team focused on the dynamic functional use of a prosthesis by the primary team member—the patient.

Partial or total loss of the UL and the associated harmful impact to motor, sensory, perceptual and biomechanical systems coalesce to influence the amputee's rehabilitation process. Of these, research suggests the potential sequelae of conditions status post UL amputation include lateral curvature of the thoracic spine. This orthopaedic abnormality in conjunction with deficits in motor systems, may have a negative influence on the dynamic function of the upper quadrant. Occupational therapists experienced in treatment of UL amputation patients utilize evidence-based methods of treatment to mitigate the physical deficits impacting functional UL prosthesis use. A review of literature to examine the effects of UL amputation to the upper quadrant and a broad view of the applicable therapeutic modalities to address resultant deficits will be presented. Specific emphasis will be given to the rehabilitation team approach to dynamic postural control for UL prosthesis use in functional activity.

THORACIC LATERAL SCOLIOSIS

A non-profit organization, The War Amps, states on its patient information page for amputee health and medical issues, "There may be a tendency, due to the weight imbalance for the amputee's spine to curve (scoliosis)." [1] This statement is supported by research specific to UL amputation. A 1996 study by Greitmann, et al, finds,

"Upper limb amputations cause, in correlation to weight loss, a shift of the trunk to the side of the amputation, a scoliosis with a bowing to the side of the amputation, an elevation of the shoulder on the amputation side and a torsion of the trunk." [2] Likewise, a 1965 study of 72 Finnish soldiers with UL amputation and the related late sequelae reported, "Scoliosis of the thoracic spine must be considered a characteristic deformity in upper limb amputees, based on the investigators' findings in which 92 per cent of the above-elbow amputees and 67 per cent of the below elbow amputees presented this condition clinically." This author goes on to say, "radiologically, the frequency of thoracic scoliosis was significantly greater in upper-limb amputees than in other groups (P,0.05). In all above-elbow amputees, the thoracic curve was convex toward the side of the stump." [3]

Changes in curvature of the spine have also been noted in the pediatric limb loss population. "Scoliosis is not an uncommon finding in children with amputation, no matter what the etiology. There is need for careful examination of the entire child on both initial and follow-up visits, with further evaluations and prompt institution of appropriate treatment measures whenever indicated." [4]

THERAPEUTIC INTERVENTION CONSIDERATIONS

Smurr, et al, succinctly summarize the factors influencing the amputee's physical performance when operating a UL prosthesis. Of these, gross motor effects are highlighted. "Gross motor refers to range of motion and body symmetry. After limb loss, the client frequently compensates with shoulder elevation on the affected side." [5]

Changes in curvature of the spine and subsequent shoulder elevation stand to have a negative effect on the function of the upper quadrant and utilization of a prosthesis via musculoskeletal changes when engaging the scapula for UL activity. Additionally, as quoted in Rehabilitation of the Hand and Upper Extremity, "...early elevation of the scapula is a sign of scapular compensation for a weak rotator cuff and/or a stiff glenohumeral joint capsule. This shrugging motion has been associated with increased upper trapezius activity." [6] The smooth activation of muscles acting on the

scapula to elicit movement at the humerus is sometimes referred to as glenohumeral synergy, or scapulohumeral rhythm. A malfunction of this action can be referenced as scapular dyskinesis. "Scapulohumeral rhythm is the coordinated and synchronous movement of the shoulders osseous structures driven by the muscular and ligament systems." [6] In addition to training related to the systemic insults related to amputation, occupational therapists are trained in the assessment and effects of shoulder dyskinesia on functional use of the UL.

Research is limited regarding UL amputation's resultant affects of stresses to the thoracic spine and related treatment techniques to mitigate detrimental effects. Corio, et al, completed a study of individuals with LL loss on the effects of spinal stabilization exercise on the spatial and temporal parameters of gain. This study suggests spinal stabilization exercise training may be effective in improving selected spatial and temporal parameters of gain as a part of an overall rehabilitation program in individuals with lower limb loss through strengthening of the core muscles of the trunk, especially the transverse abdominis and multifidus." [7]

Research specific to a neurophysiological basis of trunk control in adolescent idiopathic scoliosis reveals, "Trunk control is generally carried out by means of very fast, feedforward or feedback driven patterns of muscle activation which are deeply rooted in our neural control system and very difficult to modify by training." [8] They proposed augmenting rehabilitation via bracing as a method of continuous sensory stimulation that could help awareness of body misalignment as sensory feedback.

The application of the knowledge gained from studies such as these may enhance treatment protocols to meet a patient's ability to dynamically manipulate a UL prosthesis for functional use.

THERAPEUTIC INTERVENTION OPTIONS

Research related to intervention methodologies to mitigate effects of thoracic lateral scoliosis and upper quadrant function specific to UL amputation is limited. However, therapists may apply evidence based therapeutic interventions known to be effective in treatment of the known sequelae of deficits status post UL amputation.

Thorough patient evaluation includes assessment of the spine and the dynamic function of the scapulae. Fundamental treatment methods include musculoskeletal strategies for optimal range of motion, strengthening, conditioning, neuromuscular training with repetitive drills and dynamic functional activities and psychosocial intervention and adaptive techniques training. Occupational therapists may also utilize a variety of deficit specific interventions to augment this training.



Figure 1: Spine & Scapular Stability Assessment-Trans Radial Amputee



Figure 2: Spine & Scapular Assessment-Shoulder Disarticulation Amputee

Treatment Strategies-Lateral Thoracic Scoliosis

Research related to the benefits of treatment specific to the neurophysiological effects on function of the spine support utilization of common supportive therapeutic treatment techniques with UL amputees.

Supportive treatment techniques may include virtual movement and mirror therapy to enhance cortical organization of movement. "Functional magnetic resonance imaging (fMRI) studies suggest ongoing stimulation, muscular training of the stump and visual feedback from a myoelectric prosthesis might have a beneficial effect on both cortical reorganization and phantom limb pain." [8]

Studies hypothesize the use of augmented sensory feedback and strength exercise could be an important stage in a rehabilitation program aimed at hindering, or possibly reversing, scoliosis progression. [8] Similarly, therapists may utilize kinesiology taping in addition to physical training to enhance proprioceptive and facilitory feedback. A study in the Journal of Electromyography and Kinesiology found the "application of Kinesio taping over the lower trapezius muscle improved the lower trapezius activity during 60-30° of the lowering phase of arm scaption, and increased scapular posterior tilt at 30° and 60° of arm scaption." The authors suggest Kinesio taping could be a useful therapeutic and prophylactic assistance both in the rehabilitation clinic and in the field. [9] The concepts for utilization of this treatment technique may prove useful for UL amputee training for body awareness training.

Therapeutic intervention for pain mediation related to peripheral nerve insult is also a valuable tool for treatment of the UL amputee. Therapist attention to neural tension, neuromuscular conditioning, posture with activity and

education for optimal musculoskeletal tissue healing is necessary.

UL amputees are often placed in the position of mapping new motor learning outside of their years of physical development. As such, learning new motor skills can be an exceptional challenge. Progressive repetitive training for high level dynamic prosthesis function is required for optimal motor mapping. A treatment mindset similar to that used when training athletes or musicians may be advantageous. Internationally recognized athletic training and conditioning expert, Vern Gambetta explains functional training this way, "Function employs an integrated (as opposed to isolated) approach. It involves movement of multiple body parts, and the movement involves multiple planes. It is not a matter of functional or non-functional; rather it is an understanding of how functional a particular movement or exercise is relative to the training objective." [9]

REHABILITATION COLLABORATION

As members of the rehabilitation team, it is imperative to be aware of the training and research results other team members bring to this topic. According to Donatelli, "One of the most direct relationships between the spine and the shoulder girdle is through muscle, tendon and fascial attachments." [10] Smurr, et al reports, "Coordinating therapy efforts to address the overall physical deficits associated with amputation are imperative." [5] She goes on to address the importance of partnering with physical therapists to address postural symmetry and training. "Use of a combination of methods to train for optimal dynamics performance of the upper quadrant is indispensable." [5]

The research of Yancosek, et al, highlights the opportunities to learn from the research and training of both occupational and physical therapists skilled in treating amputees. Their 2009 study on the effects of UL prosthesis use during gain in patients with concomitant LL loss highlights the effects of upper quadrant function on gait. This report surmises, "Trunk rotation and associated arm swing are critical components to human gait. Arm swing has also been purported as the motion that is useful in counteracting the trunk rotation in gait. Further, it has been suggested that abnormal trunk motion in any plane may result in decreased stabilization and poorer locomotor control." [11] This study also found that the difference between the gait pattern of the uninjured control group versus the UL/LL amputation group were fewer when the subjects wore their prostheses. This result is an example of meaningful information available for the UL amputation rehabilitation team. Patients generally perform functional tasks in a dynamic fashion such as standing, walking, bending and reaching. The use of a UL prosthesis to perform these tasks calls for an overarching team approach to rehabilitation.

CONCLUSION

It is essential to develop a comprehensive approach to rehabilitation within the context of occupational therapy and likewise the rehabilitation team. The foundation for this approach begins with the healthcare professionals working in partnership with the patient. Successful functional operation of an UL prosthesis is comprised of the coordination of intervention to address the many physical systems affected.

Further research is required to definitively ascertain the functional result of these physical insults specific to UL amputation. Longitudinal studies to ascertain the effects of UL amputation on the thoracic spine and presence of subsequent scapula dyskinesia with comparison of effects by amputation level may be of benefit. Subsequent research to identify the therapeutic treatment techniques best suited to prevent or diminish the negative impact of these effects on dynamic functional prosthesis use will enhance UL patient rehabilitation and success.

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