

Case Reports

Apprehension-Based Training: A Novel Treatment Concept for Anterior Shoulder Dislocation – A Case Report

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Background and Purpose

Conservative management of anterior shoulder dislocation (ASD) is associated with greater recurrence compared with surgical management. Current rehabilitation protocols may not adequately challenge shoulder stability to encourage adaptive coping strategies. Apprehension-based training (ABT) is a new treatment concept derived from the supine moving apprehension test (SMAT), a previously validated performance measure among patients with ASD. The purpose of this case report is to describe the application of ABT in a patient with recurrent ASD.

Study Design

Case report

Case Description

The subject was a 23-year-old male with bilateral recurrent ASD. The subject underwent a 17-week exercise program involving gradual exposure to increased anterior instability loads based on the SMAT movement pattern. The Western Ontario Shoulder Instability Index (WOSI), Patient-Specific Functional Scale (PSFS), Tampa Scale of Kinesiophobia, SMAT, shoulder internal and external rotation muscle strength were measured via hand-held dynamometry before and after training.

Outcomes

Following treatment, clinically meaningful gains in quality of life (WOSI) and shoulder function (PSFS) were noted. Kinesiophobia decreased, SMAT and shoulder internal rotator strength increased beyond their respective minimal detectable change. Four months after treatment, quality of life and shoulder function remained improved, and the subject reported a reduced rate of ASD.

Discussion

Apprehension-based training involving gradual exposure to shoulder instability loads may hold potential for improving the management of patients with ASD. Further testing of this concept is warranted.

Level of Evidence

4, single case report

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BACKGROUND AND PURPOSE

Anterior shoulder dislocation (ASD) is common among young and active individuals.^{1,2} While surgical management is associated with lower rates of recurrence,³ most people seem to prefer to avoid surgery after a first-time ASD.⁴ Conservative management is also the initial treatment of choice by many athletes who wish to resume competitive participation within the same sporting season.^{5,6} This choice is not without consequence as individuals following ASD exhibit fear of re-injury and fear of movement which often lead to avoidance behavior and a resultant lower quality of life.⁷⁻⁹

Evidence supporting the conservative management of ASD is insufficient. One case series lacks a detailed description of the rehabilitation protocol,¹⁰ while the exercise protocol described in another case series does not include any exercise in the apprehension position (i.e. shoulder abduction and external rotation) which, in the opinion of the authors, may not challenge anterior shoulder stability adequately.¹¹ A single randomized controlled trial indicates better functional outcomes after a neuromuscular exercise program compared with home strengthening exercises.¹² Adequate exposure to conditions simulating ASD seems particularly important to stimulate the development of effective neuromuscular coping strategies. Exposure to activities considered fearful by patients with ASD may also serve to lessen the fear associated with shoulder movement and facilitate greater participation in daily and recreational activities. Such an approach has been previously shown beneficial among patients with chronic low back pain.^{13,14}

The supine moving apprehension test (SMAT)¹⁵ is a physical performance measure designed to assess the ability to control excessive shoulder horizontal abduction and external rotation which are often implicated in the mechanism of ASD.¹⁶ The SMAT movement pattern may also serve as a mechanism to train patients with shoulder instability to develop effective neuromuscular control strategies that may allow for improved coping with anterior instability. Additionally, a progressive exercise intervention derived from the SMAT may provide graded exposure to conditions that cause fear, which may help decrease apprehension, and promote greater confidence and willingness to use the shoulder. Apprehension-based training (ABT) is a new treatment concept derived from the SMAT. The purpose of this case report is to describe the application of ABT in a patient with recurrent ASD.

CASE DESCRIPTION

HISTORY

A 23-year-old left-handed male (height: 181 cm, weight: 81 kg) electrical engineering student presented with complaints of a seven-year history of bilateral shoulder instability. The subject reported dislocating his left shoulder for the first time at the age of 17 while playing soccer. The shoulder was reduced on-field with the help of a paramedic. One month later the subject suffered a right ASD also while playing soccer, but this time the shoulder was self-reduced

on field. Over the years the subject described multiple bilateral ASD's, more frequently on the left side than the right. The subject reported experiencing a left ASD at least once monthly and a right ASD once every few months. These dislocations were typically self-reduced. A magnetic resonance arthrography (MRA) of the left shoulder demonstrated an anterior-inferior labral tear as well as a Hill-Sachs lesion. An MRA of the right shoulder demonstrated an anterior inferior and posterior labral tear and a chronic Hill Sachs lesion. Given the subject's preference for conservative management he was referred multiple times to physical therapy over the years. Informed consent was obtained from the subject prior to collecting history and physical examination.

PHYSICAL EXAMINATION

Observation revealed no atrophy over the rotator cuff or deltoid, scapular alignment was symmetrical with no apparent winging or anterior tilting, no biceps abnormality or acromioclavicular step deformity were noted. Active range of motion (ROM) of the right/left shoulder into forward flexion (163°/169°), abduction (180°/173°), external rotation (with arm held by the side) (60°/55°) and internal rotation in the behind the back position (to the level of T3/T4 spinous process) were within the normal limits for a young male.^{17,18} Passive flexion ROM could not be tested in the supine position and passive external rotation ROM could not be tested in the supine or standing position due to apprehension. Passive internal rotation at 90° of abduction of the right/left shoulder was within normal limits (73°/68°, respectively).¹⁹ Shoulder internal rotator (IR) and external rotator (ER) muscle strength was tested in the supine position using a hand-held-dynamometer (HHD) with the shoulder positioned at 90° of abduction and neutral rotation (the preferred position of 90° abduction and 90° of external rotation could not be assumed due to apprehension). The dynamometer was placed over the dorsal (for ER strength) or volar (for IR strength) aspect of the distal forearm and two, 5-second repetitions of a "make" test were performed with the subject exerting maximal ER or IR effort and the examiner providing an equal and opposing resistance through the HHD. The repetition yielding the highest strength value was recorded. Baseline ER/IR strength on the right was 21.1/18.7 kg, corresponding to an ER/IR ratio of 1.12 and on the left was 16.0/20.8 kg (ER/IR ratio 0.77). The ER/IR ratio measured in this testing position in an overhead athletic population is reported to be 0.91 and 0.94 on the dominant and non-dominant shoulder, respectively.²⁰

OUTCOME MEASURES

The Western Ontario Shoulder Instability Index (WOSI) – The WOSI is a 21-item shoulder instability-related quality of life measure. Each item is scored on a 100 mm visual analogue scale resulting in a total score between 0 – 2100 which can be converted to a percentage with greater scores indicating greater disability.²¹ The WOSI has excellent test-retest reliability (intraclass correlation coefficient (ICC)

0.95,²¹ and a minimal clinically important difference (MCID) of 220 points (10.4%).²²

Tampa Scale of Kinesiophobia (TSK) – The TSK is a 17-item fear of movement and reinjury measure. Each item is scored on a 4-point Likert scale for a total score between 17 to 68 with scores greater than 37 representing high fear of movement.^{23,24} The MDC of the TSK has been reported as 10 points.²⁵

The WOSI and TSK were administered first immediately following informed consent (pre-test) and again 8 days later (baseline) to establish their stability. The WOSI and TSK scored 84.5% and 50 points, respectively during pre-test, and 88.6% and 52 points during baseline.

The Patient-Specific Functional Scale (PSFS) – The PSFS is a self-reported functional ability measure. The subject selects three daily activities affected by their condition and rates the level of difficulty in performing these activities on three separate 11-point (0 – 10) numeric subscales with 0 indicating “no difficulty” and 10 indicating “complete inability”. The average score of the three subscales serves as the total score of the PSFS. The PSFS has shown high test-retest reliability among patients attending physical therapy for shoulder complaints with an ICC 0.87 (95% CI 0.72, 0.94) an MDC 1.0, and an MCID 1.3.²⁶ The subject’s baseline PSFS score was 7.7/10.

Anterior apprehension test – The anterior apprehension test which is typically scored dichotomously (positive/negative) was rated on a 4-point (0 - 3) ordinal scale for the purpose of this study, with a higher score representing less apprehension. Rating was based on the phase of the test in which apprehension was elicited as detected by resistance to further movement, or verbal expression of fear. The examiner stood behind the sitting patient and stabilized the scapula to prevent retraction. The examiner then abducted the shoulder to 90° (score 0), externally rotated the shoulder maximally (score 1), horizontally abducted the shoulder behind the frontal plane (score 2), and finally abducted the shoulder beyond 90° (score 3). The test was scored 0/3 bilaterally during baseline assessment.

Supine moving apprehension test - The SMAT is performed in a supine position by repetitively moving the arm to 135° and 180° of shoulder abduction over a 1-minute period while holding a dumbbell equaling 3% body mass.¹⁵ The test is scored based on the number of repetitions completed over a minute and has been shown to possess construct and concurrent validity among patients with ASD.¹⁵ The ICC and MDC of the SMAT are 0.84 and 10 repetitions and 0.74 and 12 repetitions on the dominant- and non-dominant side, respectively.¹⁵

For safety reasons the procedure for the SMAT begins with assessment of the ability to control both end-range positions of the test (i.e. 135° and 180° of shoulder abduction in a supine lying position with the elbow straight while holding a 2 kg weight). If the subject is unable to control either position the SMAT is scored 0. If the subject can control both positions the dynamic test is performed beginning with the weight held in front of the chest. The subject then moves the shoulder to 135° of abduction, returns to the starting position and then moves the shoulder to 180° of

abduction and then returns to the starting position. Completion of this cycle consists of one repetition of the test.¹⁵ As the subject was unable to place the shoulder in either position (135° or 180°) on either side the SMAT was scored 0 bilaterally during baseline assessment.

ASSESSMENT

The history, physical examination, and imaging findings suggested the subject presented with bilateral, chronic, recurrent ASD. Based on the scores of all self-reported measures and the clear apprehension and unwillingness to move during ROM testing it was apparent that the subject presented with a markedly reduced quality of life due to shoulder instability and high levels of fear of movement. The subject was scheduled to begin treatment one week following baseline assessment.

APPREHENSION-BASED TRAINING (ABT)

Treatment was provided by a fellowship-trained sports physical therapist with 25 years of experience in managing musculoskeletal shoulder disorders. Two physical therapist students who had completed all didactic education in musculoskeletal physical therapy were responsible for coordinating visits to the clinic, administering self-reported outcome measures, and maintaining weekly phone contact with the subject to ensure compliance with the exercise program.

The ABT was designed to enable the subject to achieve a SMAT score of a healthy young male population (i.e. ≥ 30 repetitions/minute).¹⁵ This approach was believed to progressively increase loads on anterior shoulder stability as well as to gradually expose the subject to fearful conditions. The ABT, which is described in detail in [Table 1](#), is comprised of three phases: endurance (4 weeks), dynamic (5 weeks), and neurocognitive (4 weeks). Each phase consists of one exercise which is performed daily and becomes progressively more challenging with each consecutive week by altering joint position, weight, speed of movement, or cognitive load. A clinic-based treatment session was scheduled each week to verify proper performance and determine readiness to progress. Progression was contingent upon completion of the previous week’s exercise with satisfactory demonstration, as well as the subject’s judgment of readiness to progress. The next level of exercise was then demonstrated to the subject and practiced in front of the physical therapist. If both subject and therapist agreed it was possible to progress, the exercise was performed during the following week until the next treatment session.

The aim of the endurance phase was to increase the ability of the glenohumeral adductors, extensors, and internal rotators to control outer range shoulder horizontal abduction and external rotation moments. Concomitantly, this allowed for a gradual exposure to shoulder positions that are typically avoided due to apprehension. The gradation of forces was achieved by progressing from a lighter to a heavier weight and by progressing from training in the scapular- to the frontal-plane ([Figure 1, a – d](#)).

Table 1. Apprehension-based exercise program description.

Phase	Week	Mode	Hand-held weight ^a	Dose/pace	Comments
Endurance	1	Isometric	1 kg	<ul style="list-style-type: none"> • 30 X 10 seconds at 135° abduction • 30 X 10 seconds at 180° abduction 	Scapular plane
	2		1 kg	<ul style="list-style-type: none"> • 30 X 10 seconds at 135° abduction • 30 X 10 seconds at 180° abduction 	Frontal plane
	3		2 kg	<ul style="list-style-type: none"> • 30 X 10 seconds at 135° abduction • 30 X 10 seconds at 180° abduction 	Scapular plane
	4		2 kg	<ul style="list-style-type: none"> • 30 X 10 seconds at 135° abduction • 30 X 10 seconds at 180° abduction 	Frontal plane
Dynamic	5	Isotonic (SMAT movement pattern)	2 kg	• 3 X 1 minute at 10 RPM ^b	Set order of movement.
	6			• 3 X 1 minute at 15 RPM	
	7			• 3 X 1 minute at 20 RPM	
	8			• 3 X 1 minute at 25 RPM	
	9			• 3 X 1 minute at 30 RPM	
Neurocognitive	10	Isotonic (SMAT movement pattern)	2 kg	• 3 X 1 minute at 25 RPM	Random order of movement.
	11			• 3 X 1 minute at 30 RPM	One arm at a time
	12			• 3 X 1 minute at 25 RPM	Random order of movement. Both arms simultaneously
	13			• 3 X 1 minute at 30 RPM	

RPM, repetitions per minute ^a Weight is based on the participant's body mass: 1.5% during weeks 1-2, and 3% thereafter. ^b Initial pace set based on patient's ability.

The aim of the dynamic phase was to train the subject to produce and control the dynamic movement pattern of the SMAT (repeatedly extending the arm to 135° and 180° of abduction while lying in a supine position and holding a 2 kg weight). Gradation of forces was achieved through a progressive increase of the pace of movement up to 30 repetitions-per-minute (RPM) which is thought to represent normal SMAT performance (Supplementary videos 1 – 3).¹⁵ The initial pace (10 RPM) was set based on a shared therapist-patient decision, and an attempt was made to increase the pace by five repetitions each consecutive week. The subject used a metronome application on his smartphone to help maintain the prescribed exercise pace. Increasing movement pace was thought to place greater horizontal abduction and external rotation momentum which was hypothesized to further challenge anterior shoulder stability

and concomitantly expose the subject to more fearful conditions.

During the neurocognitive phase the subject continued to perform the SMAT movement pattern at a relatively high pace (25 – 30 RPM) however the order of arm movement (135° or 180°) was unpredictable and in response to numeral commands. Audio files including randomly ordered double-digit numbers comprised of the numerals 1 and 2, or 3 and 4 (i.e., 11, 21, 34, 44) were pre-recorded and sent to the subject's smartphone. The subject was instructed to extend the left arm to the 135° position in response to the numeral "1", extend the left arm to the 180° position in response to the numeral "2", extend the right arm to the 135° position in response to the numeral "3", and extend the right arm to the 180° position in response to the numeral "4". Accordingly, in response to the number "11" the



Figure 1. Endurance phase: (a) 135° scapular-plane abduction; (b) 180° scapular-plane abduction; (c) 135° frontal-plane abduction; (d) 180° frontal-plane abduction.

subject was required to extend the left arm to the 135° position twice in a row, and in response to the number “43” the subject was required to extend the right arm to the 180° position followed by the 135° position. During the first two weeks of the neurocognitive phase the subject exercised each arm separately while during the last two weeks both arms were trained simultaneously (Supplementary videos 4, 5). The neurocognitive phase incorporates elements of attention, dual-tasking, reaction time, and memory. The addition of cognitive demands to a physical task has been previously shown to decrease performance during lower extremity functional tests such as hopping and a change of direction.^{27,28} The inclusion of such elements is in accordance with current views on the need to design rehabilitation procedures and return-to-play testing to simulate the chaotic conditions of competitive sports more closely.²⁹

Following the completion of the intervention the subject was scheduled for a final assessment which included the three self-reported outcome measures (WOSI, TSK, PSFS), a repeat examination of IR and ER muscle strength, the anterior apprehension test and SMAT. Four months after treatment the subject was contacted to report any additional instability episodes and to again complete the WOSI, TSK and PSFS.

OUTCOME

The subject was able to complete the intervention within 17 weeks. The program lasted four weeks longer than expected as during the 3rd week of the program (endurance phase) the subject suffered a left shoulder dislocation while reaching into the backseat of his car. The dislocation was self-reduced within a few seconds, however this resulted in the need to rest the shoulder for 10 days. In addition, the subject needed an extra two weeks of training to progress from a pace of 25 to 30 RPM during the dynamic phase (week 8),

as well as an extra week of training to progress from a pace of 25 to 30 RPM during the neurocognitive phase (week 12).

At the end of the training period the subject reported greater confidence and willingness to use the shoulder during daily activities. [Table 2](#) summarizes pre-test, baseline, post-treatment, and follow-up self-reported measures, while [Table 3](#) summarizes baseline and post-treatment physical examination measures.

The WOSI and PSFS improved well beyond their respective MCID following treatment,^{22,26} while the TSK score improved beyond its reported MDC.²⁵ The SMAT score of both shoulders increased well beyond their respective MDC,¹⁵ and shoulder IR muscle strength improved beyond the MDC previously reported for a similar testing methodology.²⁰ Shoulder ER muscle strength remained unchanged. The anterior apprehension test was still positive bilaterally, but apprehension was elicited in a more advanced stage of the test in both shoulders. Finally, passive ROM into shoulder flexion and external rotation was possible with no apprehension and measured 175°/170° and 80°/86° on the right/left side.

Four months after treatment the WOSI and PSFS remained improved, however TSK score increased close to its baseline level ([Table 2](#)). The subject reported one additional dislocation of the right shoulder which occurred immediately after the treatment period as he was getting dressed after an MRA of his right shoulder. The dislocation was self-reduced, and no additional dislocations have occurred since. Therefore, over an 8-month period (from the beginning of treatment to four months following treatment) the subject experienced one dislocation of each shoulder. The subject considered this to be a clear reduction of the rate of shoulder dislocations. Finally, the subject reported continuing to exercise at a frequency of once a week.

Table 2. Pre-test, baseline, final, and follow-up self-reported outcome measures.

Measure	Pre-test	Baseline	Final	4-month follow-up	Minimal detectable change or MCID
WOSI (%)	84.5	88.6	55.7	54.2	10.4 ^a
TSK (17 – 68)	50.0	52.0	35.0	47.0	10.0
PSFS (0 – 10)	NT	7.7	3.0	3.7	0.97 ^a

PSFS, Patient-specific Functional Scale; TSK, Tampa Scale of Kinesiophobia; WOSI, Western Ontario Shoulder Instability Index. ^a Minimal clinically important difference

Table 3. Pre- and post-treatment physical examination measures.

Measure	Pre-treatment	Post-treatment	Minimal detectable change
Right IR strength (kg)	20.8	22.2	0.97 – 1.60
Left IR strength (kg)	18.7	23.6	0.97 – 1.60
Right ER strength (kg)	16.0	16.0	1.30 – 1.43
Left ER strength (kg)	21.1	21.5	1.30 – 1.43
Right SMAT (repetitions) (non-dominant side)	0	25	12
Left SMAT (repetitions) (dominant side)	0	28	10
Right anterior apprehension (0 – 3)	0	2	NA
Left anterior apprehension (0 – 3)	0	3	NA

ER, external rotation; IR, internal rotation; SMAT, supine moving apprehension test.

DISCUSSION

A novel exercise program specifically designed for patients with ASD was successfully implemented in the care of a patient with bilateral recurrent ASD. Following intervention clinically meaningful gains in quality of life and functional ability were observed along with reduced kinesiophobia and increased willingness to move the shoulder. The SMAT score improved beyond the random error associated with this test.¹⁵ The change in SMAT score and final SMAT score were well above those observed among patients after surgical stabilization and post-operative rehabilitation.¹⁵ Furthermore, the final SMAT score for both shoulders was only slightly below the score of a healthy young male population.¹⁵ Collectively, these results suggest ABT may hold potential in improving the conservative care of patients with ASD.

The ABT is unique in that it is focused on obtaining control of a specific movement pattern that is known to be deficient among patients with ASD.¹⁵ The basic premise behind the program is that confrontation with progressively increased shoulder apprehension conditions will facilitate neuromuscular and psychological adaptations that will result in increased confidence and willingness to use the shoulder during activities of daily living.

Previous studies suggest delayed and reduced activation of muscles with potential to control excessive shoulder horizontal abduction and external rotation such as the pectoralis major and subscapularis.^{30,31} Such neuromuscular

deficits may play a role in the mechanism of recurrent ADL. The ABT was designed to improve the function of these muscles as well as other muscles with potential to prevent excessive horizontal abduction and external rotation such as the teres major, latissimus dorsi, and biceps brachii. Although the specific muscle activation pattern associated with ABT has not yet been reported, it is theorized that the supine lying position with the shoulder at 135° or 180° of abduction as performed in the endurance phase elicits activation of these muscles. The rapid acceleration of the shoulder into the 135° and 180° positions during the dynamic and neurocognitive phases is thought to invoke reactive activation of the adductors and internal rotators of the shoulder to decelerate the arm at end-range and accelerate it back to the starting position. Gradually increasing the pace of this movement creates plyometric training conditions, which has been previously shown to elicit joint protective neuromuscular adaptations such as improved proprioception and kinesthesia, faster production of maximal torque, and decreased amortization time from external to internal rotation.³² Although the authors did not assess for these adaptations after treatment, there was an increase in shoulder IR but not ER muscle strength following treatment, suggesting muscle-specific adaptations had occurred.

Patients with recurrent ASD have been shown to exhibit increased kinesiophobia,^{7,8} and persistent avoidance of certain daily and sport-related activities.⁹ Increased activation of brain networks regulating motor resistance, cognitive

control of movement, anxiety, and emotional regulation has been elicited in patients with anterior shoulder instability when visually presented with movements associated with anterior shoulder apprehension.³³ Given these findings, it would seem that patients with ASD may benefit from psychological-based interventions such as graded exposure which has been successfully used among patients with chronic low back pain.¹⁴ The ABT provides a simple and feasible platform for providing such graded exposure in the context of ASD. The progressive confrontation with anterior instability loads may lead to habituation and degradation of the apprehension response. This may have been manifested by a decrease in kinesiophobia at the end of the treatment period, an increased tolerance to the anterior apprehension test and passive ROM testing, and an improved performance of the SMAT.

Despite the decreased rate of ASD and the clinically meaningful improvement in most outcome measures, the subject remained affected by shoulder instability as manifested by a relatively high WOSI score, a positive apprehension test and the recurrence of kinesiophobia at follow-up. While long-term disability and persistent apprehension have been documented years after surgical stabilization of the shoulder,^{9,34} incorporating additional elements into ABT should be considered. Exercises in this case report were performed solely in the supine lying position. While this provides for a controlled progression of anterior destabilizing forces, it does not consider the variety of circumstances under which ASD might occur.³⁵ Incorporating the control of the same movement pattern in other positions or under weight-bearing and/or closed kinematic conditions may serve to lessen kinesiophobia and disability even further.

Another consideration is adaptability. The ABT may need to be modified based on the individual needs of patients. For example, early after an acute ASD, patients must first regain full active ROM prior to beginning the ABT protocol. In contrast, patients who can perform the SMAT relatively well at baseline may be allowed to progress more rapidly through the initial phase of the program. Finally,

patients presenting with impairments possibly contributing to shoulder instability such as scapular dyskinesis or rotator cuff strength deficits, should be prescribed additional exercises to address such impairments.

This case report has several other limitations. Most importantly, a case report cannot infer a cause-and-effect relationship between intervention and outcome. Only a randomized controlled design can prove whether ABT yields results that differ from those of other interventions or the natural history of ASD. Second, no long-term follow was performed, and outcome is limited to the immediate- and short-term periods only. Third, the mechanism behind the clinical improvement observed following treatment is unclear. Although a decrease in kinesiophobia was evident, possible other mechanisms relating to neuromuscular control were not assessed. Fourth, because no interim outcome assessment was carried out, it is unclear what was the value of each of the three phases of the ABT in obtaining the outcome. And finally, the reliability of the anterior apprehension test as performed and scored in this study was not previously determined and findings relating to this outcome need to be interpreted with caution.

CONCLUSION

Apprehension-based training, an intervention specifically designed for patients with ASD, was successfully completed by a subject with bilateral recurrent ASD. Clinically meaningful gains in quality of life and functional ability were detected, along with a reduced rate of shoulder dislocations, decreased kinesiophobia, increased willingness to move, and an improved SMAT score. Further study is warranted to explore the feasibility and efficacy of this intervention among patients with ASD.

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SUPPLEMENTARY MATERIALS

Supplementary video 1. Dynamic phase RPM 10

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Supplementary video 2. Dynamic phase 20 RPM

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Supplementary video 3. Dynamic phase 30 RPM

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Supplementary video 4. Neurocognitive phase – unilateral training 30 RPM

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Supplementary video 5. Neurocognitive phase – bilateral training 30 RPM

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