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A case study of technical change and rehabilitation: Intervention design and interdisciplinary team interaction

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8 A Case Study of Technical Change and Rehabilitation: Intervention Design and

9 Interdisciplinary Team Interaction

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14 Suggested Running Head: TECHNICAL CHANGE AND REHABILITATION

15 INTERVENTION

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Abstract

The design of effective interventions in sport psychology often requires a subtle blend of techniques, tailored to meet the client's specific needs. Input from a variety of disciplinary support specialists, working as a team, is also frequently needed. Accordingly, this study investigated an interdisciplinary team approach to the technical change and rehabilitation of an elite weight lifter following injury; necessitating the avoidance of regression when performing under competitive pressure. Multiple coaching approaches were used and complimented by targeting specific mental skills. Kinematic analyses indicated progressive technical, and subsequently permanent, change even after 2 years. Self-report measures of self-efficacy and imagery use were deemed essential in facilitating the change. Finally, a discussion focuses on the intervention's multifactorial nature, its application within high performance coaching, and how this may advise future research into the refinement of already existing and well-established skills.

Keywords: skill refinement, pressure resistance, elite performer, motor imagery.

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43 Interdisciplinary Team Interaction

44 Athletic injury is an unfortunate but common reality in sport, especially when coupled
45 with a strong desire to win under high competitive pressure; this reality is particularly
46 apparent in elite-level weight lifting. Although there are many factors that may contribute to
47 injury, for example inadequate warm-up behaviors (Woods, Bishop, & Jones, 2007) or
48 under/overtraining (Baquie & Brukner, 1997), in many power-oriented sports, injury may
49 often be attributed to poor movement execution (Hedrick & Wada, 2008). Accordingly, in
50 circumstances where an athlete possess a well-established, and automatically controlled (i.e.,
51 subconsciously) technique (Fitts & Posner, 1967), but shows consistent movement error, the
52 option of technical change can become a crucial consideration, both in the interest of safety
53 and ensuring future competitive participation. Hence, understanding how to optimize this
54 process should be of significant interest to both athlete and coach.

55 A major concern when changing technique in sports such as weight lifting is failure to
56 change correctly *but also* securely (i.e., making change resistant to the effects of competitive
57 pressure). In such cases, this failure can result in further chronic injury and a permanent
58 absence from high-level participation. This scenario presents a serious problem when
59 working with elite athletes, since their habitual tendencies have been shown to be robust
60 under conventional coaching instruction (Jenkins, 2008), making technical regression a
61 distinct possibility (cf. MacPherson, Turner, & Collins, 2007). From a psychological
62 perspective, additional complexity comes when the change required is associated with a
63 current need for physical rehabilitation caused by injury (Podlog, Dimmock, & Miller, 2011).
64 Clearly these circumstances present an even greater need for interdisciplinary consideration
65 towards training design, most obviously from physiotherapy, motor control, and sport
66 psychology perspectives.

67 Addressing this scenario, technical change interventions must be implemented both
68 deliberately and sensitively within the rehabilitation process; adopting a perspective of
69 extended psychological compared to physical rehabilitation. Magyar and Duda (2000)
70 support this suggestion, finding that injured athletes receive their greatest source of
71 confidence from their initial judgments of the rehabilitation setting and when perceptions of
72 coach leadership and social support are high. These findings also clearly substantiate the
73 need for interdisciplinary teams. Importantly however, is the scope of holistic contribution
74 that may be provided by the sport psychologist—utilizing a *package* approach of several
75 complimentary techniques in combination to bring about technical change and, subsequent
76 security to competitive pressure (cf. Martindale & Collins, 2012).

77 Consequently, this paper describes an exemplar intervention strategy used to refine
78 the technique, self-perceptions, and performance of an injured elite weight lifter. The
79 multifactorial nature of the intervention and intent to bring about change correctly and
80 securely is particularly emphasized. Furthermore, the paper offers an insight into the use of
81 an interdisciplinary team, addressing questions concerning some theoretical research and its
82 application for performance enhancement. However, before explaining the theoretical
83 perspectives underlying the intervention, a description of the problem will be provided.

84 **The Athlete and Focus for the Intervention**

85 The athlete in question, “J,” was a male, elite Olympic weight lifter, at the time in
86 transition from the National junior to senior squad. In attempting to qualify for the
87 Commonwealth Games, which were to be held in August, the athlete was required to compete
88 at the British Championships in June of the same year. It was following these championships
89 that the coaches and sport psychologist decided to intervene; the issue being forced by injury,
90 brought on by a long-term technical fault. This was coupled with the need to be fit, and
91 technically safe, for the Commonwealth Games only 10 weeks away.

92 The incident occurred during the first phase of the competition, the two hand snatch.
93 In this lift, “the bar shall be placed horizontally in front of the lifter’s legs. It is gripped,
94 palms downwards and pulled in a single movement from the platform to the full extent of
95 both arms above the head” (Hartfield, 1994, p. 53). Although athlete J performed one legal
96 snatch of 105 kg, he received a Grade 2 sprain to the ulna collateral ligament of the right
97 elbow, which was verified by the team doctor and later by the team physiotherapist. From
98 film of the event, the coaches identified, subjectively and independently, that the technique
99 was “flawed” and probably led to the injury. Furthermore, they confirmed to the sport
100 psychologist and physiotherapist that this flawed technique was a common feature of this
101 athlete’s lifting, and that coaches had previously attempted to rectify this using contemporary
102 corrective coaching procedure (i.e., their normal repertoire of coaching “tools”).

103 **Injury and Technical Evaluation**

104 During training it was common practice for the sport psychologist to film the lifters
105 from the sagittal plane (side on). Two-dimensional analyses were regularly undertaken of
106 important lifts. In addition, during the British Championships, we performed a three-
107 dimensional analysis of the lifters (see method section). From these two sources, we were
108 able to obtain information concerning the angular displacements of the right arm complex.
109 These data proved invaluable in verifying the opinions of the coaches and providing support
110 pertaining to the etiology of the injury; findings which were independently assessed by the
111 team doctor and physiotherapist. Data also provided the team with two important facts about
112 the case. Firstly, the technique employed by athlete J was consistent. These data
113 demonstrated that the lifter was executing a similar movement strategy both during and prior
114 to the injury (Figure 1). Secondly, the cause of the injury was determined. Through the
115 application of both kinematic data and conventional diagnostic procedures, it was suggested
116 that the injury was caused by valgus strain (functional abduction) of the right elbow joint.

117 This movement is normally inhibited by the ulna collateral ligament. The athlete had been
118 aware of this problem for some time; however, the combination of the weight attempted plus
119 flawed technique resulted in a partial rupture of the ligament. Despite his appropriate
120 concerns, prior to the intervention, the athlete had been unable to complete the technical
121 change indicated by both data and coaches.

122 Based on the case history, the following aims for the intervention were determined; to
123 (a) rehabilitate the injury through contemporary clinical practice, (b) correct the technique in
124 order to minimize further injury potential, and (c) improve athlete J's mental and physical
125 readiness for the Commonwealth Games, 10 weeks away.

126 **Theoretical Rationale for the Intervention**

127 **Flaws in technique.** “Bad habits” or *systematic behavioral biases*, may be caused by
128 a variety of different mechanisms, including, as a direct result of progressive incorrect skill
129 acquisition (Walter & Swinnen, 1994). Thus, errors in performance appear to be able to
130 “creep up” on the best of athletes. Furthermore, many coaches and some psychologists have
131 highlighted that, if an athlete becomes too experienced in a particular movement pattern,
132 there is little possibility of technical change over a short period of time (see Hanin, Korjus,
133 Jouste, & Baxter, 2002). Indeed, it has been shown that at this stage of motor learning, such
134 movement techniques have been automated (controlled subconsciously) and are therefore
135 highly resistant to change when using conventional coaching practice (Maschette, 1985, cited
136 in Hanin et al., 2002) or unaided by external guidance (cf. MacPherson et al., 2007). More
137 optimistically however, a review by Walter and Swinnen (1994) suggested that, “some
138 performers may have particular difficulty in dissolving ‘bad habits’ that have emerged early
139 in learning. These individuals may especially benefit from training strategies that are
140 specifically designed to help the individual depart from their preferred movement pattern” (p.

141 509). There is, therefore, a highlighted need to further investigate the refinement of
142 technique in such individuals.

143 From a motor control perspective, laboratory-based research could be used to inform
144 this departure process. Findings have shown that the stability of a to-be-learned movement
145 over time is dependent on its proximity to the already well-established (i.e., stable) movement
146 pattern (Kostrubiec, Tallet, & Zanone, 2006). In summary, the greater the distinction
147 between these two movement patterns, the more persistent the new memory trace will be. By
148 contrast, more similar to-be-learned movements demonstrate initially higher levels of
149 accuracy, but weaker characteristics in terms of long-term stability; suggesting that
150 movements which are similar to the already well-established technique, may be harder to
151 permanently stabilize. Certainly coaches report this to be the case in athletics field events
152 (Trower, 1996), which is of particular concern when a time constraint is placed upon the
153 intervention, as in this case of elite weight lifting. Crucially however, the findings of
154 Kostrubiec and colleagues run contrary to the suggestion of maintaining “automization” over
155 the existing technique, representing a *continuously* implicit level of control (Rendell, Farrow,
156 Masters, & Plummer, 2011), while undergoing technical change. Automization, which
157 characterizes well-learned and pressure resistant skills at high-levels of performance, must be
158 initially “deautomated” (cf. Beilock, Bertenthal, McCoy, & Carr, 2004; Oudejans, Koedijker,
159 & Beek, 2007). In fact, several applied studies have already exploited the movement
160 deautomation process by introducing *contrast training* as a means of generating this
161 necessary and conscious distinction (see Collins, Morriss, & Trower, 1999; Hanin et al.,
162 2002), before reautomating the technique under conditions of lower conscious control (i.e.,
163 change as a nonlinear process). Notably, however, despite the fact that contrast drills are an
164 established and clearly useful element of the change process, scarce data exists on the
165 potential optimization of effects when undertaking a technical change intervention, and the

166 inherent challenges with this process, through the complementary use of effective mental
167 skills. Such skills as imagery (Winter & Collins, 2013), observational learning (Ashford,
168 Bennett, & Davids, 2006), and being able to realistically evaluate performance (MacNamara,
169 Holmes, & Collins, 2008) are all valuable skills in enhancing the potential for skill
170 development. Accordingly, it was a key goal for the coaching team, including the sport
171 psychologist, to provide appropriate training in mental skill development as well as providing
172 the athlete with a prognosis to the technical flaw.

173 **Imagery and observational learning.** The most predominant intervention technique
174 used by sport psychologists to overcome skill disorders is imagery, or mental practice
175 (Morris, Spittle, & Watt, 2005). This technique initially requires the covert formulation of a
176 physically practiced behavior. The behavior is then manipulated or reinforced, often by
177 means of verbal propositions from the psychologist. However, the generation of images
178 through verbal proposition can be arduous, particularly if the individual is not well practiced
179 at the target behavior, or unsure of the exact demands placed upon them. To support these
180 individuals, one tool which can be used to generate vivid and controllable images is
181 observational learning. Rushall (1988) defined the observational learning procedure as “the
182 learning of new behaviors or the altering of existing behaviors by imagining scenes of others
183 interacting with the environment” (p. 132).

184 A number of theories have been proposed to explain the observation–behavior
185 relationship. Probably, the most complete attempt was forwarded by Bandura (1977, 1986),
186 who proposed that observation is one of the primary modes used by individuals to develop
187 cognitive skills. Bandura explained that symbolic representation, or verbal coding, takes
188 place when one views a particular model. This representation is then used as a referent for
189 the establishment of a new behavioral pattern. Further support for this notion exists from
190 Lang’s (1979) bioinformational theory, which relates to a cerebral structure of associated

191 neural networks, or cell assemblies. Each network is formed, based upon the information
192 from the environment (intrinsic and extrinsic stimulus propositions) and semantic elaboration
193 (meaning propositions) of the information encoded in memory. These networks are linked to
194 encoded information about responding, using both somatomotor and autonomic nervous
195 systems (response propositions). Inputs or cues that match concepts represented by the
196 associative networks serve to activate that particular network. Given a sufficient number of
197 matches between the perceptual information and that encoded within memory, the entire
198 network is activated and processed as a unit, based upon the response information linked to
199 that cue (cf. Smith, Holmes, Whitemore, & Devonport, 2001). From this, it would seem
200 logical to expect that a strong perception–action link will exist between the environmental
201 cues and the subsequent action and, therefore, likely to be more facilitative with elite athletes
202 (McCullagh, Weiss, & Ross, 1989); a possible reason being that an elite athlete will have had
203 prolonged exposure to stimulus, response, and meaning propositions. In summary, both
204 observational learning and imagery strengthen or weaken associations between
205 environmental cues and responses, thereby changing or reinforcing the associated neural
206 network. The result is a modification or consolidation in the behavior.

207 Imagery interventions usually take the form of an imagery script which is, at least
208 initially, read to the athlete. Observational learning, by contrast, takes the form of live or
209 video demonstrations. Unlike an imagery script, where the information has been refined to
210 produce a controllable and vivid image, a video demonstration contains task irrelevant, as
211 well as task relevant information. Researchers have consequently argued that model
212 characteristics affect other relevant processes, such as the attentional capacity of the observer.
213 For example, McCullagh (1986) showed that individuals who observed a model with a
214 perceived high-status level performed better on a Bachman ladder test than individuals who

215 observed a low-status model. Accordingly, it seems essential that the model contains the
216 characteristics which are considered to produce an optimal rate of technical change.

217 A prevalent debate exists regarding the optimal type of model used in the
218 observational learning process (see Ste-Marie et al., 2012, for a review). For example, there
219 are two types of model commonly under contention in the literature: the skilled “perfect”
220 model, and the learning or coping model. By far the more popular of the two is the skilled
221 model, whereby the observer watches a skilled performer complete the required movement
222 pattern. It is argued that the skilled model demonstrates optimal characteristics of a particular
223 movement pattern, thus providing the observer the opportunity to internalize a perfect
224 technique in memory. This perceptual “blueprint” could then be compared to concurrent
225 action and adjustments could be made as necessary. However, according to Lang’s theory
226 (and subsequent empirical evidence from mirror neuron research; cf. Holmes & Calmals,
227 2011), there would be less association between the environmental information (the model)
228 and the responses. In summary, it merely appears that a skilled model has evolved to be
229 accepted as the norm, perhaps due to its ability to explicitly, and therefore more easily,
230 highlight the stark contrasts between the learner’s and model technique.

231 This insistence on a perfect example is also in contrast to much of the skill acquisition
232 literature. According to research into effective practice design, studies have found that, when
233 a learner is administered a program that requires greater levels of mental processing during an
234 acquisition period, improvements in outcome results are often delayed compared to when
235 conditions are made easier (i.e., require lower mental processing). Interestingly however,
236 employment of this practice design consistently leads to superior long-term retention and
237 transfer. Examples of ways in which this effect can be achieved include, providing less
238 frequent feedback, distributing practice sessions, and making the task more random in nature
239 (Cross, Schmitt, & Grafton, 2007; Schmidt & Bjork, 1992). Neuroscientific theories explain

240 this phenomenon through cortical reorganization increasing the capacity to resolve various
241 stimuli (internal or external), therefore determining what is learned. By generating the
242 conditions required to enhance the distinction between different stimuli this, in turn, results in
243 a learned response associated with the multiple representations and a change in the neural
244 networking (i.e., hard wiring; cf. Mercado, 2008). Thus, more effective behaviors are learned
245 when presented with greater variation and inevitably error. Moreover, another important
246 outcome concerns the learner being able to evaluate their own movement behaviors
247 (Shadmehr, Smith, & Krakauer, 2010). Therefore, the use of a skilled model in the covert
248 equivalent could potentially debilitate the individual's power of movement evaluation, quite
249 apart from the impact on the subject's self-efficacy (Bandura, 1986).

250 For these reasons it is suggested that the use of a coping model to support mental
251 practice may best facilitate the process of technical change. A coping model does
252 demonstrate flaws in technique, however, if the flaws are similar to the observer's, then he or
253 she can relate more closely (greater meaning propositions) to the model than if it were closer
254 to perfection, in accordance with Lang (1979). The current research on coping versus expert
255 models has produced equivocal findings (Ste-Marie et al., 2012). However, Ste-Marie et al.
256 suggest that many studies are methodologically weak. Furthermore, we suggest that the cited
257 research does not consider the confounding factors inherent in observational learning
258 (observer characteristics and other model characteristics) when making a long-term technical
259 change to an already well-established skill. Our technical change intervention is, therefore,
260 derived from the theoretical propositions offered by Lang (1979) and Bandura (1977). While
261 there have been mixed views on model type and technical change, the research on model type
262 and self-efficacy seems to be more supportive of the use of coping models. Such models
263 have been used to good effect in a variety of settings, such as social skills training (Kazdin,
264 1982). During injury, coping models have been reported to reduce the level of negative

265 emotions and increase self-efficacy for the challenges of the rehabilitation process (e.g.,
266 Maddison, Prapavessis, & Clatworthy, 2006). As the proposed intervention utilized an
267 injured performer this evidence supports the use of a coping model.

268 Reflecting these issues, the present intervention used a coping model as the
269 demonstration to the athlete. Furthermore, the athlete himself was used as the model.
270 According to Lang's bioinformational theory (1979), the covert image produced during
271 mental imagery should be as close to the overt equivalent as possible. In such circumstances,
272 a maximal match between the environmental cues and the representation in memory exists.
273 The use of a self-model should logically allow a strong recall of associated behaviors and
274 result in a more efficient process of technical change. This, in conjunction with showing
275 adaptive behaviors inherent in a coping model, would lead to the generation of a "best self-
276 model." Based on previous theoretical positions, this should maximize relevance and lead to
277 enhanced self-efficacy while progressively adjusting the technical flaw. In practice, this
278 requires the regular and progressive change in the model presented to demonstrate and
279 "shape" the technique towards the target behavior (Figure 2).

280 Despite the mechanism proposed by Lang (1979), which can explain why self- and
281 coping models are the most effective options, it could be argued that the combination of the
282 two could be potentially detrimental to the athlete. If the two are combined, the individual
283 will see their imperfect performance, which may have an inevitably detrimental effect upon
284 self-efficacy. In this regard, Rushall (1988) initially instructed an athlete to visualize a
285 complete stranger performing rather than the athlete himself in order to positively influence
286 self-efficacy. However, this apparent contradiction in the literature may well be due to the
287 "automatically negative" perception which is expected in response to error feedback. An
288 individual will only perceive an error as negative if those errors are perceived as threatening
289 to their performance enhancement (cf. Carron, 1988, on the effects of positive information

290 based reward on intrinsic motivation), a common case when the changes needed are not
291 known or seen as possible. If an accepted solution is provided in association with error
292 feedback, however, the athlete knows what to do to improve, and is empowered to make the
293 change. It would seem hard to imagine a negative response to this, so long as the performer
294 felt that they were capable of effecting the desired change (hence the use of a self-model).

295 **Intervention Design**

296 In light of the above factors, to generate the optimum intervention design, we focused
297 on these essential components:

- 298 • The athlete's technique had to change quickly, permanently, and be subsequently robust
299 under pressure.
- 300 • From an imagery perspective, response propositions/kinesthetic consequences had to be
301 maximized but also be accurate to the "new version" skill being refined.
- 302 • Self-efficacy throughout the process had to be high, thus progress had to be demonstrated
303 to, and accepted by, the athlete.
- 304 • The whole process had to enhance but never inhibit the rehabilitation process.

305 At each stage, the lifter's own performance which best approximated the target
306 behavior was used as the model for practice. Since the weight lifted is low (to avoid
307 reinjury), the athlete can quickly generate a good approximation of the target technique,
308 albeit that the movement feels extremely unnatural at first. This approach maximizes
309 accurate "feel" for the new technique (the lifter has just executed what he sees, thus
310 kinesthetic memory is high) and stresses the progress which has been made but always offers
311 an achievable target behavior. Such feel is crucial to technical change, particularly in a sport
312 like weight lifting (Lephart, Pincivero, Giraldo, & Fu, 1997). Boyce (1991) suggests that the
313 "show and tell" paradigm of modeling is a minimalist rationale for motor performance

314 enhancement. Of the possible modeling strategies, only self-modeling offers a clear
315 reference to how the movement felt.

316 **Method**

317 **Kinematic Data Collection**

318 The use of kinematic data offered a highly objective evaluation of the intervention's
319 efficacy. It also provided clear evidence to J that he had, indeed achieved the desired change.
320 During the three-dimensional analyses, the specific technique employed subscribed to the
321 Direct Linear Transformation method (DLT; Abdel-Aziz & Karara, 1971). This allowed
322 relatively flexible placement of the cameras during filming, which can be a problem at
323 competitive events. A Peak Performance (Peak Performance Technologies, Inc.) triaxial
324 calibration structure was placed over the lifting area, encompassing the volume where the
325 lifting would occur, just prior to the actual event. The two cameras were genlocked in order
326 to synchronize the opening of the two camera shutters. Videos obtained from the two- and
327 three-dimensional analyses were digitized using a software package developed and reported
328 by Bartlett and Bowden (1993). During the two-dimensional analyses that took place during
329 training, the camera was positioned perpendicular to the sagittal plane in order to measure the
330 relative angle of the shoulder and elbow at the catch phase of the snatch lift.

331 After the British Championships, a retrospective kinematic analysis of the snatch lift
332 was performed on five male weight lifters. This was to determine whether the deformation at
333 the elbow observed in J was normal during such lifts. It was considered by the coaching staff
334 that his movements were not normal.

335 **Self-Perceptions**

336 Throughout the intervention no formal questionnaires were administered to the
337 athlete. The authors deemed it inappropriate to complicate or cloud the athlete's recovery
338 with psychometric tests. Instead, the athlete reported on simple, almost self-designed scales,

339 whether he was feeling good about his progress and confident that he would do well in the
340 forthcoming Commonwealth Games. For example, a 10-point Likert scale was used to
341 answer questions on the vividness and controllability of imagery (two questions) and the
342 level of efficacy that the athlete would improve. In all cases, athlete J operationally defined
343 what the numbers represented and knew what change looked like. The coach would ask him
344 to rate his performance and provide a subjective description as to why he gave that score.
345 This became a useful part of his goal setting. Furthermore, an additional, indirect indication
346 of elevated efficacy was identified through the goals that he set for himself.

347 **Support Team Dynamics**

348 The support team consisted of two National coaches, one physiotherapist, one doctor,
349 and two sport psychologists. The team would meet at least once a month during squad
350 training. However, the person who made the final decisions pertaining to the intervention
351 was athlete J, thus empowering him to take control of his own progress. Hence, while
352 coaches provided the technical expertise, and the psychologists facilitated the technical
353 change through instilling and developing mental skills, the athlete was the central figure
354 during the intervention process. The physiotherapist and doctor rehabilitated the injury and
355 issued consent to progress through the intervention.

356 **The Intervention**

357 The process was divided into five chronologically based stages:

358 **Stage one (Weeks 0–2).** During the first 2 weeks after the injury, athlete J received
359 intense physiotherapy to reduce any inflammation and prevent the development of scar tissue
360 forming around the ligament. With the consent of the physiotherapist and doctor, the
361 psychologists and coaches intervened.

362 In practical sessions, the athlete assumed the receive position of the snatch, that is, he
363 stood in a squat position with the bar above his head (the point where the injury was known

364 to have taken place). He began by holding a broomstick handle above his head to ensure a
365 reduced possibility of relapse. The position of the bar was manipulated in the sagittal plane
366 by the coaches, while the athlete reported on how each position felt—generating a contrast in
367 kinesthesia and realizing the change. After several manipulations, the athlete was asked to
368 establish a series of self-generated cues for the different positions. For example, the athlete
369 reported feeling his arms moving backwards once he had assumed the receive position. This
370 process was important to establish awareness of the various positions.

371 Also, the athlete was encouraged to discuss the injury, and the reasons underlying it,
372 with members of the support team. Previous discussion between the members of the support
373 team meant that the athlete received a consistent message pertaining to the cause and the
374 potential solution to the problem, and the future prognosis for his lifting.

375 **Stage two (Weeks 2–4).** By now, the athlete was able to lift a 20 kg Olympic bar. It
376 was important to resume lifting the Olympic bar for two main reasons. Firstly, the use of a
377 bar offered enhancement to the athlete's kinesthesia whilst representing his return to genuine
378 lifting. Secondly, Zatsiorski (1995) stated that increased resistance will inevitably lead to
379 increased recruitment, rate coding, and synchronization of motor units within the muscle
380 fibers. If more motor units are activated, then there is a greater chance of kinesthetic
381 feedback and awareness of contrast. Thus, the maximal weight allowed by the
382 physiotherapist was attempted.

383 The athlete completed a series of repetitions, each consisting of a *correct* lift followed
384 by an *incorrect* lift. This was to distinguish kinesthetic sensations between the two lifts. The
385 emphasis was eventually placed upon the correct lifts by systematically fading out the
386 incorrect lifts. This stage required the athlete to strengthen his ability to discriminate
387 between, and evaluate the performances. During this stage, the athlete was asked to generate
388 further cues regarding the kinesthesia which discriminated the good and bad lifts, thus

389 developing a heightened kinesthetic awareness, and an increased acceptance and comfort
390 with the new version. An example of an incorrect lift would be “increased tension in the
391 chest,” while a correct cue would be “weight on the balls of my feet.”

392 Also, at this stage, J started to view his injurious performance on video, had the joint
393 angle data and its significance explained, and was debriefed on the preparation (both training
394 and precompetition) factors which he felt had led to it. By these means, understanding of the
395 problem and solution were clarified and an action plan and a series of goals were developed.
396 These provided J with a clear pathway to recovery, consisting of steps which he was
397 confident he could achieve. The provision of a multifaceted plan, which included technical,
398 psychological, therapeutic, medical, and nutritional advice (J had to maintain a body weight
399 for his weight classification), meant that some degree of personal success was almost
400 inevitable. At this point through self-report measures used to monitor the intervention, J
401 reported increased confidence about retaining full fitness and refining his technique in
402 preparation for the Games.

403 Finally, at this stage, J began to work regularly on his imagery skills (he was already
404 reasonably proficient due to previous educational work), focusing on the other Olympic lift,
405 the two hands clean and jerk, which was comparatively unaffected by his injury.

406 **Stage three (Weeks 4–6).** While Stage two was concerned with the discrimination
407 and fading of kinesthesia between correct and incorrect catch positions, Stage three focused
408 more on the consolidation of the correct movements through the use of mental skills. J’s self-
409 generated cues were clarified through discussion with his coaches, largely to establish their
410 technical appropriateness. Once clarified and agreed, cues were then incorporated into an
411 imagery script. The athlete started to image snatch performances (three to four times a week)
412 both visually and kinesthetically, while reporting what he felt and saw, and how easy it was
413 to form the image. Following recommendations consequent to the bioinformational imagery

414 approach (Cuthbert, Vrana, & Bradley, 1991), progressive reinforcement and elaboration of
415 the self-generated cues was used. So for example, as the athlete reported feeling the weight
416 of the bar on his shoulders, this was incorporated into a refined imagery script, which
417 continually evolved through ongoing debriefs and further refinement, as a method of shaping
418 the desired technique.

419 Evolution of the script, and the imagery process itself, was consolidated by the use of
420 self-modeling on prerecorded, edited videotapes. At regular intervals, J was filmed as he
421 executed physical practice of the new version on light weights. He was encouraged to
422 regularly watch this series of lifts, which provided him with an obviously improving profile
423 of performance. Thus the improvements made during mental practice, were consolidated by
424 the observation of his most recent best attempt. As the athlete improved, the model presented
425 was changed to reflect the adaptive behavior (see Figure 2). The decision to update the best
426 self-model was collaboratively decided between the athlete and coach. Video footage was
427 also included of “big” lifts on the two hands clean and jerk, to maintain and enhance his
428 confidence in this lift.

429 Finally, a longer-term plan was developed leading up beyond the Commonwealth
430 Games to the Olympic Games, to be held in 2 years’ time. This was to further reinforce his
431 positive long-term prospects.

432 **Stage four (Weeks 6–9).** With consent and ongoing monitoring by the team doctor
433 and physiotherapist, J was instructed to build up the weight and the number of repetitions. As
434 increased weight was added, the imagery script was adapted and the best self-model was
435 changed for a more optimal model, serving to reinforce J’s self-efficacy. The potential for
436 movement regression was addressed through constant coach supervision, reference to the
437 most recent best self-model, and imagery practice. It was essential that J met the targets that
438 he set himself during the early stages of the intervention. These targets reflected increased

439 weight as well as process goals pertaining to the technique and mental skills. So far, he had
440 been progressively and explicitly challenged by his own targets. More importantly, he had
441 attained all of his goals.

442 **Stage five (Weeks 9–10).** Once athlete J had resumed lifting maximal weights, he
443 was subjected to competitive simulated environments during training. The inclusion of added
444 pressure (presence of selectors, gentle “baiting” by other team members, etc.) and the ability
445 to provide feedback both qualitatively (via immediate video review) and quantitative (by
446 means of kinematic information) were important facets of this final stage, as a way of
447 convincing both J and the coach that the change was secure and therefore should not be
448 altered again. Performance feedback and debrief with the coaches and the athlete was used to
449 yet further refine the imagery script. The imagery which had been developed over a period of
450 6 weeks was incorporated into a pre-event preparation strategy.

451 **Results**

452 **Technique**

453 It was decided at the initiation of the intervention that J would need to flex the
454 shoulder joint so that the force of the bar would act directly through the arm. During the
455 injury, the force was acting behind the shoulder joint center. This created a large torque at
456 the elbow and shoulder joints in both the right and left arm. Unfortunately, the torque
457 required to correct the direction of force was so large that the ulna collateral ligament
458 eventually ruptured. Figure 3 shows the angular displacements relative to the sagittal plane
459 (not the absolute values) for the right shoulder and elbow (compare these with the targeted
460 change shown in Figure 1). As the intervention progressed, the angle at the shoulder and
461 elbow were minimized straightening the arm and positioning it in the direction of force.
462 Consequently, the torques developed during earlier lifts were progressively reduced in the
463 shoulder and elbow. This, in turn, reduced the pressure on the injured limb.

464 Figure 3 demonstrates the progressive shift towards recovery during the intervention.
465 Furthermore, three follow up data acquisitions are included to demonstrate the long-term
466 permanence of the technique change. There is an ongoing, albeit slight, improvement even 1
467 year after the cessation of the intervention, which was maintained at a 2 year follow-up.

468 **Self-Perceptions**

469 Two important psychological features were considered during the intervention. The
470 first was self-efficacy, the second was imagery performance. Initially, athlete J set himself
471 targets that he felt he would attain at least 80% of the time. As the intervention progressed,
472 the tolerance for his targets were self-reduced to 60% and finally, to 40%. Although this is
473 not a direct indicator of improved self-efficacy, it does reveal athlete J's efficacy to attain
474 more demanding goals. During stage one of the intervention, athlete J reported an average
475 efficacy score of 3. This was based on the immediacy of the injury, countered by his trust in
476 the support team. During stages two and three, this score increased to 4. Athlete J reported
477 that the rate of improvement seemed slow and his perception of performance readiness for the
478 Commonwealth Games was in doubt. However, he was improving and therefore increased
479 his score. By stage five, his average self-reported efficacy score had increased to 7;
480 demonstrating an improvement in his self-efficacy over the intervention's duration and
481 remained at this score at all follow up assessments. However, due to the ideographic nature
482 of case studies, we stress that these results do not represent a common and standardized
483 measure of improvement, since they are personal to the operational definitions laid down by
484 each athlete. In this intervention, the Likert scores were used as a stimulant for discussion,
485 which was deemed to be of much greater importance.

486 With regard to imagery ability, J reported increasingly high levels of vividness and
487 controllability through the intervention which persisted over 3 years after the intervention
488 during a future examination of all lifters in the weightlifting program. A post hoc review of

489 the process showed that J perceived his ability to “come back from” the injury as a formative
490 experience and an achievement in itself.

491 **Performance**

492 Performance wise, it is pleasing to report that J trained hard to the limits of his
493 potential and competed in the Commonwealth Games completing a maximum of three out of
494 three snatch lifts. Furthermore, he continued to improve his technique; as was evident at the
495 following year’s British Championships (see Figure 3, Week 55), the absence of subsequent
496 injury, and his personal best of 107.5 kg at the next European Union Championships 2 years
497 later. His subsequent established status as a National squad athlete (for 5 years post injury)
498 and consistent selection for international competition, also attests to the quality of his
499 recovery.

500 **Discussion**

501 It is particularly important for sport psychology as a discipline, and for the specific
502 client–psychologist interaction, that the efficacies of interventions are increasingly
503 demonstrated through objective measurement. Consequently, the present intervention
504 utilized kinematic techniques and performance measures, as well as the more usual self-
505 report indices, to provide this evidence. On evaluation of the elbow and shoulder kinematics,
506 there appeared to be a great deal of positive change. The athlete successfully refined the
507 injurious technique in accordance with the suggested manipulation through the observational
508 learning and imagery-based procedure. Consequently, this served to enhance specific
509 psychological characteristics, his career, and performance development.

510 As a notable feature of the case study presented, we advocate the systematic use of
511 multiple tools to facilitate technical change in skills that are already well-established, coupled
512 with necessary positive psychological change. In this particular case, we used contrast
513 training to differentiate movement patterns followed by a progressive shaping methodology,

514 and concluding with necessary steps to internalize and then increase resistance to stressors
515 through appropriate pressure testing. Whereas previous studies have employed similar
516 techniques as contrast training, for example Hanin et al.'s (2002) "Old way/New way," we
517 suggest that shaping and pressure testing are essential *additional* steps to ensuring a robust
518 departure from one movement pattern to another.

519 From a technical perspective, the theoretical research by Walter and Swinnen (1994)
520 suggests that athletes with an already well-established technique could possess bad habits as a
521 result of incorrect skill acquisition. Fortunately, this has been shown to be resolvable, and in
522 a short time period. Experimentally, Zanone and Kelso (1992) explained that smaller
523 changes would be more realistic in such circumstances, owing to the high level of similarity
524 between the two behavioral states; however, this appeared to disagree with findings from the
525 applied setting (Trower, 1996). Indeed, later research confirmed this view, demonstrating
526 that close similarities between behaviors result in only short-term permanency when
527 compared to movements that were more distinct from one another (Kostrubiec et al., 2006).
528 Relating these findings against our applied intervention, it appears that this research does not
529 sufficiently represent the totality of challenge faced by elite-level athletes. Based on the
530 evidence in this case study, three strategies should be employed for maximum effect: contrast
531 training, then shaping, followed by pressure testing. As an essential procedure to ensure the
532 formation of a new movement pattern, conscious contrast (deautomation) between the already
533 well-established and to-be-learned pattern must take place; thus supporting the idea of
534 distinction between subtly different movement patterns. This should be followed by
535 progressively shaping the technique; supporting a process of smaller but gradually more
536 accurate approximations of the target behavior. In other words, technical change can be
537 viewed as a process of generating an "uncomfortable" alternative, although technically more

538 desirable, followed by gradually increasing the “comfort” of this new version, while at the
539 same time decreasing the comfort levels of the original version.

540 As an additional benefit of this case study, athlete J commented consistently
541 throughout the intervention on his perceived improvement in self-efficacy. One may argue
542 that efficacy developed by the athlete was more of a mediating factor in bringing about
543 change (Bandura, 1997). Indeed, observational learning, more specifically the use of coping
544 models, have been shown to increase levels of self-efficacy in comparison to the more
545 commonly employed skilled model (Ste-Marie et al., 2012). It has long been recognized that
546 imagery and observational learning interventions can serve different roles. Hall, Mack,
547 Paivio, and Hausenblas (1998) suggest that there are different “types” of images that may
548 serve either a cognitive or a motivational function. Therefore, the nature of the problem may
549 dictate whether self-coping, “other,” or mastery models would be best suited. The
550 characteristics of the task, problem, and performer should all have a bearing on the inclusion
551 of a best self-model as part of an intervention. The literature base, so far, concerns itself with
552 how a specific model characteristic affects performance. However, little effort has been
553 expended in trying to establish the optimal characteristics of a model for different
554 classifications of individuals and/or problems, such as technical change in experienced
555 populations. This case study supports the use of imagery and observational learning as both
556 informational (technical change) and motivational (self-efficacy) coaching tools.

557 In summary, this particular case study employed a series of techniques that appear to
558 have been very successful in meeting the intended outcomes for this individual. Reflecting
559 the need for established and effective training programs at this level of motor control, a
560 greater understanding of the refinement process and previously successful methods employed
561 is essential, probably again, through various case study examples (see Carson & Collins,
562 2011), with results presented in tandem with the logic underlying the decision to use that

563 particular approach (Barker, Mellalieu, McCarthy, Jones, & Moran, 2012). With respect to
564 the intervention design, it is worth noting the “trade off” decisions which were taken at each
565 stage. The complexity of the human condition, added to the various challenges of
566 competitive sport, dictate that no one approach will offer a perfect fit to the needs of the
567 intervention. Of course, this planning necessity is well known to experienced consultants (cf.
568 Murphy, 1995) but should beneficially be exposed when presenting case studies. Research in
569 a variety of settings demonstrates the importance of the reasoning process as both a feature of
570 expertise and a crucial aspect of education and professional development (Martindale &
571 Collins, 2007).

572 Although not the primary focus of this paper, another important consideration was the
573 use of an interdisciplinary support team to rehabilitate athlete J’s technique and injury.
574 Working relationships between the coaches, doctor, physiotherapist, and psychologists were
575 most important, with each having clearly defined and well accepted roles. Co-operation
576 towards a set of mutually accepted goals, with each team member telling the same story, can
577 only emerge from such a secure and prenegotiated position. Accordingly, it is a pertinent
578 part of the sport psychologist’s role to develop this team approach. The potential for conflict
579 in such teams has already been addressed (Reid, Stewart, & Thorne, 2004) but sport
580 psychology may well benefit from the application of occupational and organizational
581 approaches to optimize the sport science/sport medicine/coach/athlete dynamic (Burke,
582 2011). Consideration of all these factors will ensure that athletes receive the optimum level
583 of service.

584 More interesting however, is the approach to securing the new technique under
585 pressure. The inclusion of pressure testing as a means of building self-efficacy, coupled with
586 quantitative evidence to demonstrate that the changes had been made securely, reflects the
587 holistic nature of this case study and an important consideration of transfer to representative

588 competition. Furthermore, the notion of convincing both athlete and coach that the technique
589 no longer requires further modification (tweaking), represents an important avenue of our
590 future research concerning multiple fields, including: motor control, sport psychology, and
591 coaching practice. It is hoped that this will extend the work and contribution of sport
592 psychologists towards the achievement of excellence in elite sport settings.
593

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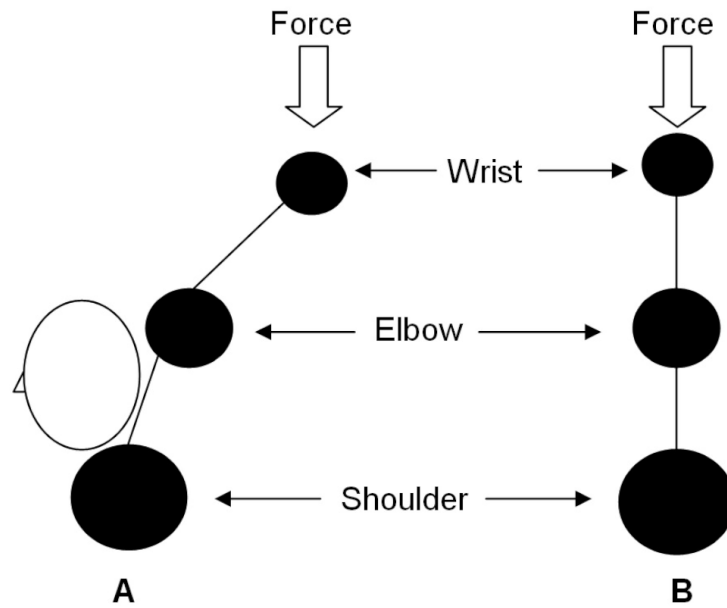


Figure 1. Schematic showing the injurious right arm complex prior to the intervention (A) and the target technical change (B) which was the goal of the intervention.

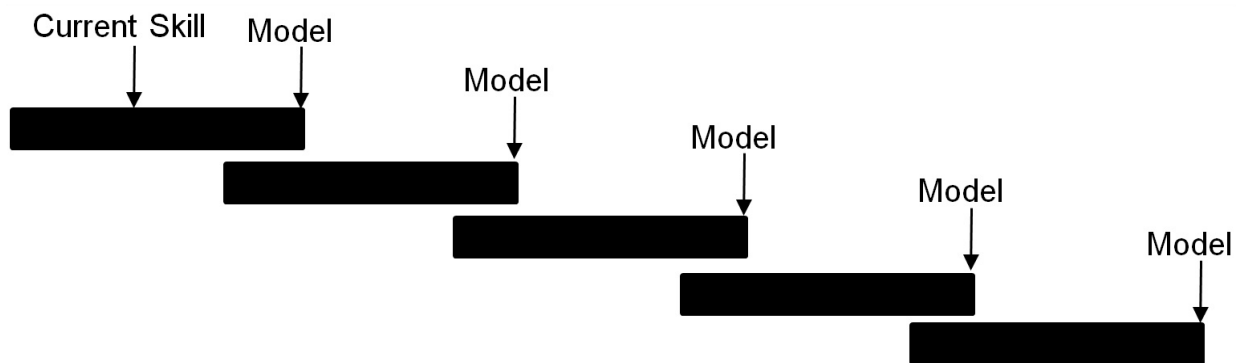


Figure 2. Shaping methodology; the athlete observes a best self-model based on his best actual attempt (closest approximation) of the target behavior. As the athlete progresses towards the target behavior, the model based on his best attempt is changed.

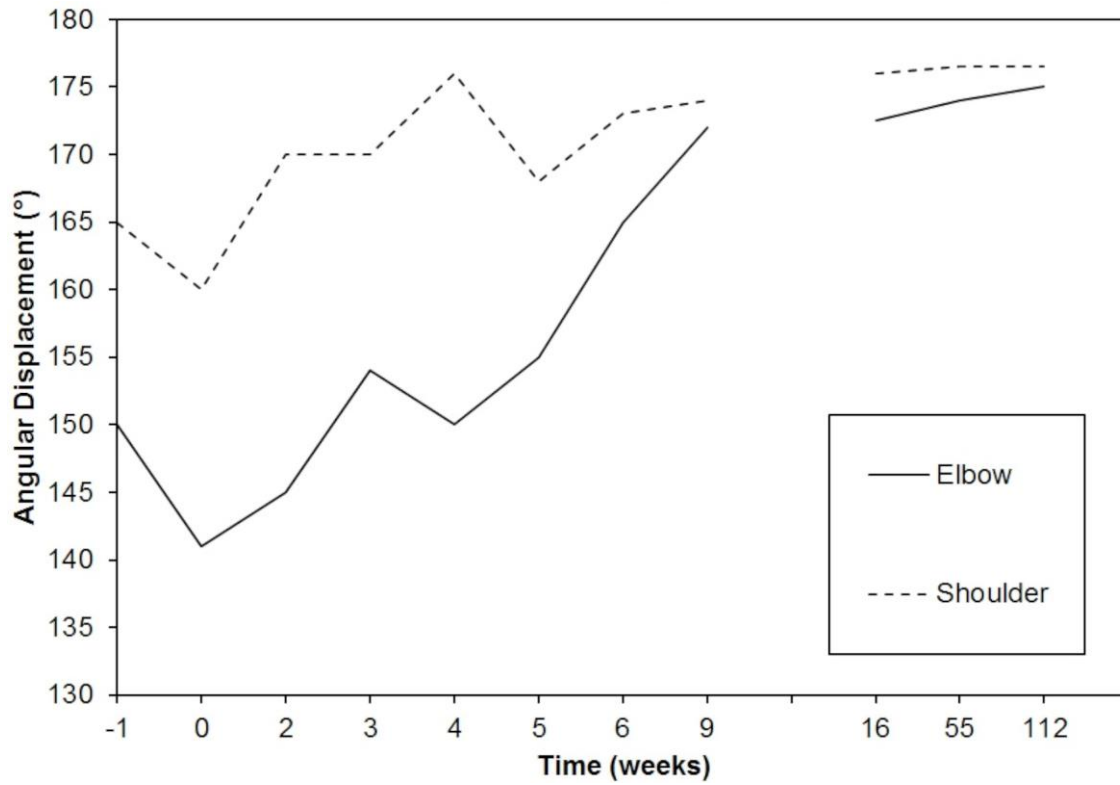


Figure 3. Lifter's angular displacement at elbow and shoulder 1 week prior to injury (-1 week), the injury itself (Week 0), through the progression of the intervention (Weeks 2-6), in competition after 1 year following injury (Week 55), and 2 years (Week 112).