Original Article

The MIQ-RS: A Suitable Option for Examining Movement Imagery Ability

Melanie Gregg[1], Craig Hall[2] and Andrew Butler[3]

[1]School of Health and Bioscience, University of East London, London, UK, [2]School of Kinesiology, The University of Western Ontario, London, ON, Canada and [3]Department of Rehabilitation Medicine, Emory University School of Medicine, Atlanta, GA, USA

Within rehabilitation settings, mental imagery helps to promote long-term recovery and facilitates compliance to rehabilitation exercises. Individuals who are able to effectively engage in imagery practice are likely to gain the most benefit from imagery training. Thus, a suitable imagery ability measurement tool for individuals with movement limitations is needed. The purpose of the present study was to evaluate the Movement Imagery Questionnaire—Revised second version (MIQ-RS), and compare the results of this new version with Hall and Martin's (1997) MIQ-R. Three-hundred and twenty participants from a variety of sports and performance levels agreed to take part. Results showed the internal consistency and test–retest reliability of the MIQ-RS were satisfactory, the two-factor structure of the MIQ-RS was supported by confirmatory factor analysis, and Pearson correlations indicated a strong relationship between the MIQ-R and MIQ-RS. It appears the MIQ-RS is a suitable option for examining movement imagery ability primarily aimed at the upper extremity.

Keywords: imagery measurement – mental imagery – rehabilitation

Introduction

Movement imagery, the mental rehearsal of visual and kinesthetic properties of movements, is a cognitive strategy that can benefit motor skill acquisition and performance enhancement in movement contexts such as sport and sport injury rehabilitation. Imagery is frequently employed to enhance athletic performance in competition, as well as aid athletes at all levels in acquiring skills (1–4). With respect to injury rehabilitation, using sport-related imagery during injury rehabilitation has been shown to facilitate an athlete's return to their sport (5,6). Furthermore, engaging in imagery during periods of immobility aids in decreasing the negative outcomes of the restricted mobility, most notably muscle atrophy and associated strength loss (7–9). The rationale for the use of imagery to promote recovery is that imagery practice may allow access to the motor network independently of movement, thereby promoting long-term recovery (10). Imagery is not currently accepted as standard practice for sports medicine or rehabilitation. Imagery use in medical and rehabilitation settings is on the rise; Goldstein and his colleagues (11) sampled over 9000 people, 23.1% of the sample reported using mind–body techniques including imagery, guided imagery, meditation/self-hypnosis and biofeedback.

Not only does imagery use facilitate motor performance, it also influences cognitions. For example, the frequent use of imagery during injury rehabilitation is related to enhanced task efficacy, or the patient's confidence in their ability to perform the prescribed rehabilitation exercises (12). In turn, an injured patient's task efficacy predicts the duration they will engage in their rehabilitation exercises. Thus, imagery use may indirectly enhance recovery as injured patients will spend more time engaged in their prescribed rehabilitation exercises.

For reprints and all correspondence: Melanie Gregg, Department of Kinesiology and Applied Health, The University of Winnipeg, 515 Portage Avenue, Winnipeg, Manitoba, Canada R3B 2E9. Tel: (001) 204 786 9820; Fax: (001) 204 783 7866; E-mail: m.gregg@uwinnipeg.ca

Given that imagery has a positive influence on motor performance, do people with higher imagery ability benefit more than those with lower imagery ability? The answer to this question seems to be yes. After reviewing the research, Hall (13) concluded that imagery ability is an important determinant in how effective the use of imagery will be in sport and exercise contexts. In line with this conclusion, Rodgers and her colleagues (14) found that athletes who are better at imagery (i.e. had a higher imagery ability rating), use imagery more frequently than athletes who are not as proficient at imagery. Moreover, as a result of using more imagery, their imagery ability improves. It follows that if imagery ability is related to the strength of the relationship between imagery use and sport performance, then it may also impact the relationship of imagery use and movement rehabilitation outcomes.

To investigate the role of imagery ability in movement rehabilitation settings an appropriate assessment tool is required. While various questionnaires have been constructed to assess movement imagery ability, the most commonly employed instrument is the Movement Imagery Questionnaire (MIQ; 15), and the shortened version of the same questionnaire, the Movement Imagery Questionnaire—Revised (MIQ-R; 16). The MIQ was initially developed for and utilized in motor learning and control research (15,17), but has also been used extensively in sport-related research (14,18). The MIQ is comprised of nine visual imagery and nine kinesthetic imagery items, each of which involves the movement of an arm, leg or the entire body. In order to complete each item, four steps are required. The starting position for each movement is described, and the participant assumes this position. The movement is then described and the participant physically performs the movement. Next, the participant retakes the starting position, and images the movement without physically performing the movement. Finally, the participant rates the ease or difficulty of imaging the movement on a 7-point scale anchored by 1 = very easy to picture/feel and 7 = very difficult to picture/feel. Psychometric evaluation of the MIQ has demonstrated good reliability and validity. Both the visual and kinesthetic imagery subscales have adequate reliability coefficients [0.89 for visual and 0.88 for kinesthetic, (16); 0.87 for visual and 0.91 for kinesthetic; (15)]. Hall *et al.* (15) also reported test–retest reliability coefficient of 0.83. Finally, Atienza *et al.* (19) found support for the two-factor structure, with all visual items loading on the first factor, and all kinesthetic items loading on the second.

Hall and Martin (16) revised the MIQ to make it applicable to a wider range of people i.e. items requiring considerable athleticism were removed, shorter and more user-friendly. The MIQ-R is comprised of four visual and four kinesthetic items, which are completed in the same manner as the items on the MIQ. Each item is rated on a 7-point scale, ranging from 1 = very hard to see/feel to 7 = very easy to see/feel. Hall and Martin (15) found that the MIQ and MIQ-R subscales were highly correlated ($r = -0.77$ for the two visual and the two kinesthetic subscales). These results indicated that the MIQ-R may be a useful substitution for the MIQ, especially when examining the imagery ability of non-athletes. While the MIQ-R can be administered to a large proportion of patients in movement rehabilitation settings, it is not appropriate for all patients. Two items on the questionnaire require people to jump straight up in the air. Performance of this task is impractical for patients with certain movement limitations (i.e. recent stroke, leg fracture, etc.) due to physical or safety limitations.

Recently, Malouin and her colleagues (20) developed the Kinesthetic and Visual Imagery Questionnaire (KVIQ) for assessing imagery ability in populations with restricted mobility. The KVIQ, similar to the MIQ and MIQ-R, has two subscales: visual and kinesthetic. For the KVIQ, kinesthetic imagery is reported as levels of intensity that could be interpreted differently than the MIQ and MIQ-R's report of feeling. Thus, it may be possible that these kinesthetic measures are actually reporting different types of imagery. Initial reliability and construct validity data indicate the questionnaire may be useful for assessing imagery ability. Although the KVIQ shows promise it does have limitations, including being time and resource intensive to administer.

It has been well documented that populations such as athletes and dancers benefit from engaging in mental imagery (21,22). In recent years, movement imagery has emerged as a promising technique to improve motor skill performance in people recovering from injury [for reviews see Braun *et al.* (23) and Sharma *et al.* (10)]. Attempts to apply movement imagery in a rehabilitation context have been made recently. For example, a 2001 study in subacute stroke patients (> 4 weeks < 1 year post-stroke) compared the feasibility and efficacy of a program that combined movement imagery and physical therapy (PT) to a program comprised only of PT, showing that combining the two therapies was a clinically feasible, cost-effective complement to therapy and may improve functional outcomes more than participation in PT only (24). Empirical assessment of the effectiveness of imagery in rehabilitation settings has been limited, focusing on small studies involving stroke patients as participants (10,23). Braun *et al.* (23) conducted a systematic review of the effects of mental practice in stroke rehabilitation. The review revealed many of the studies involved a unimanual task performed with the upper limb; such as reaching for or drinking from a cup (25–27). Often these studies involved a small sample size or case study design and combined imagery with PT (24,25,28).

Braun *et al.* (23) suggest that imagery is a skill that should be taught to rehabilitation patients; therefore, it is important to examine imagery ability as this may influence

the effectiveness of the imagery (29). Thus, mental practice in physical rehabilitation offers a potential complementary and alternative means to promote motor recovery after damage to the central nervous system. Due to task limitations of the MIQ and MIQ-R, there is a need for further revision of these instruments in order to assess movement imagery ability for populations who have restricted movement abilities and are unable to complete the MIQ or MIQ-R (10). The effectiveness of imagery interventions in rehabilitation settings have mainly been assessed in relation to arm function, though there has been some success with tasks involving the legs and feet as well (28,30). The purpose of the present study was to develop and evaluate a new version of the MIQ-R, termed the MIQ-RS, that would be suitable to administer to patients with movement limitations. The MIQ-RS requires movements of both the upper and lower limbs, thus assessing the ability to image gross motor movements. In addition, by not limiting imagery to movements of strictly the upper limb patients will have the opportunity to improve their overall motor movements for activities of daily living.

Methods

Participants

A total of 321 volunteers agreed to participate in the study; one was eliminated due to missing data. The participants had a mean age of 23.33 years (SD = 8.25) and the sample was comprised of an approximately equal number of males (146) and females (174). The volunteers were athletes and the majority participated in a sport at the varsity or provincial level (187), while the remainder were distributed among recreational/club and national/international levels. They had participated in their sport on average for 7.55 years (SD = 6.34). Sport participation represented by the sample included: track and field ($n = 82$), rowing ($n = 59$), rugby ($n = 33$), basketball ($n = 22$), the remainder were spread among 26 other sports. The original versions of the MIQ-RS (MIQ and MIQ-R) were both validated using athletic populations, to allow comparison and to test the properties of the present version a similar population was recruited.

Measurement Tools

MIQ-R

This instrument assesses visual and kinesthetic movement imagery ability and is comprised of four visual and four kinesthetic items. Each item entails performing a movement, visually or kinesthetically imaging that movement and then rating the ease or difficulty of generating that image on a 7-point scale from 1 = very hard to see/feel to 7 = very easy to see/feel. The internal consistencies

of the MIQ-R have been consistently adequate with Cronbach's α coefficients ranging above 0.79 for both the visual and kinesthetic subscales (21,22). The bi-factorial structure of the MIQ-R has also been recently confirmed using a small sample of 134 males and females, 17–60 years of age (31).

MIQ-RS

The development of the MIQ-RS involved several steps. First, the two items (one visual and one kinesthetic) on the MIQ-R that entailed jumping up in the air were removed since people with some movement impairments (e.g. recent stroke patients) would be unable to perform these actions. As a result of deleting these items, each subscale of the questionnaire (i.e. visual, kinesthetic) only contained three items. This was deemed problematic because if subsequent psychometric analysis suggested that one or more items be deleted from either or both of the subscales there would not be sufficient items to adequately represent the constructs being measured. Consequently, eight items (four visual and four kinesthetic) were added that reflected everyday movements: bending forward, pushing (an object like a door), pulling (an object like a door handle) and reaching and grasping (an object like a drinking glass). These movements were selected keeping in mind the tenants on which the original MIQ was developed [e.g. inclusion of relatively simply movements; (15)] and because these movements are commonly employed in motor control and movement rehabilitation research (32,33). It seemed logical to have imagery ability measured on some of the same movements used to assess patients' motor functioning. Therefore, the MIQ-RS is composed of two subscales, visual and kinesthetic and each of these is represented by seven items. The instructions and rating scales for the MIQ-RS are the same as for the MIQ-R (Appendix).

Procedure

Participants were approached before or after a regularly scheduled athletic practice session and asked to complete the MIQ-RS. Participants completed the questionnaire independently though the researcher administering the questionnaire was nearby to provide clarification if requested. To compare participant scores on the MIQ-RS to the MIQ-R, a convenient sample of 278 participants were requested to also complete the MIQ-R. Administration of the questionnaires was counterbalanced to avoid response bias. In addition, to assess the test–retest reliability of the questionnaires, a further sub-sample ($n = 87$; who were available to participate on more than one occasion) completed both questionnaires at two time-points with a 1-week interval between questionnaire administration.

Table 1. Descriptive statistics and distribution for the subscales

Subscale	N	Mean	SD	Skewness	Standard error	Kurtosis	Standard error
Time 1							
Visual MIQ-RS	320	5.80	0.87	−1.15	0.14	2.28	0.27
Kinesthetic MIQ-RS	320	5.55	0.98	−0.98	0.14	1.28	0.27
Visual MIQ-R	278	5.78	0.96	−0.97	0.15	1.59	0.29
Kinesthetic MIQ-R	278	5.55	1.08	−1.01	0.14	1.30	0.29
Time 2							
Visual MIQ-RS	87	5.67	0.84	−0.37	0.26	−0.55	0.51
Kinesthetic MIQ-RS	87	5.38	1.00	−0.92	0.26	0.90	0.51
Visual MIQ-R	85	5.70	0.94	−0.47	0.26	−0.66	0.52
Kinesthetic MIQ-R	85	5.36	1.15	−0.79	0.26	0.58	0.52

Table 2. Individual item analyses

Subscale	Item	Mean	SD	Regression weights
Visual	2	5.74	1.23	0.77
	4	5.76	1.13	0.78
	5	5.54	1.26	0.61
	8	5.90	1.10	0.74
	10	5.93	1.04	0.70
	13	5.90	1.20	0.63
	14	5.82	1.16	0.63
Kinesthetic	1	5.60	1.27	0.73
	3	5.60	1.21	0.80
	6	5.56	1.28	0.71
	7	5.39	1.27	0.73
	9	5.62	1.19	0.82
	11	5.63	1.22	0.76
	12	5.46	1.27	0.67

Results

Participants Score Higher on Visual Imagery

Means, standard deviations and distribution of the variables (i.e. skewness and kurtosis) are reported in Table 1 for both subscales for the MIQ-R and MIQ-RS at each time point. For each questionnaire, the visual subscale was rated highest, indicating the participants were more adept at using visual than kinesthetic imagery; $t(319) = 5.10$, $P < 0.01$. The negative skew and positive kurtosis of the data indicates a bias toward high scores of imagery ability. These skewness and kurtosis values may be due to the nature of the population (13,34) as well as the large sample size (35).

Support for a Two-factor Model of Movement Imagery Ability

Confirmatory factor analysis (CFA) was used to assess a two-factor (visual and kinesthetic) model of movement imagery ability. A number of fit indices were used to evaluate the model. The $\chi^2/\mathrm{d}f$ (Q) ratio was used as an index of absolute model fit (36). The Comparative Fit Index (CFI) and the Relative Fit Index (RFI) were employed as indicators of a global model fit (37). The root mean square error of approximation (RMSEA) was also considered to assess the discrepancy between the implied and observed correlation matrices (36). Fit indices >0.90 for CFI and RFI and <0.10 for RMSEA were considered indicative of acceptable model fit. For purposes of testing the model, the two factors were allowed to covary with one another, items were loaded exclusively on relevant factors, and the variance for each latent factor was fixed at one. Support was generated for the two-factor model: $Q = 3.72$, CFI = 0.988, RFI = 0.976, RMSEA = 0.092. The overall fit of the structural model was supported by moderate to strong standardized parameter loadings (λs ranged from 0.61 to 0.82). Estimated regression weights of the individual items for each subscale are listed in Table 2.

Imagery Ability Scores are Consistent over Time

Internal reliability of the subscales of the MIQ-RS was determined using Cronbach's α coefficients. Both the visual ($\alpha = 0.87$) and kinesthetic ($\alpha = 0.90$) subscales had acceptable internal reliability (38). For each subscale, the individual item scores were similar with small variance, see Table 2.

The test–retest reliability or stability of psychometric questionnaires typically has been assessed through the use of the Pearson (interclass) correlation. In the present study, $r = 0.83$ for the visual subscale and $r = 0.73$ for the kinesthetic subscale. Thomas and Nelson (39) suggest that the intraclass correlation should be employed when concerned with the scoring of the same variables (items) across time. Thus, intraclass correlation coefficients (ICC) were also calculated to examine the reliability of the individual items of MIQ-RS. The ICC values for the visual items ranged from 0.54 to 0.72 and the values for the kinesthetic items ranged from 0.54 to 0.73.

Modified Imagery Ability Measure has Concurrent Validity

To make comparisons between scores on the MIQ-R and MIQ-RS Pearson correlations were calculated.

Both subscales had strong correlations between the questionnaire subscales: visual (0.82) and kinesthetic (0.80).

Discussion

Visual Imagery Ability Outscores Kinesthetic Imagery Ability

The results of the study demonstrate that the MIQ-RS shows reliability and validity. Furthermore, as with the MIQ-R (16), a two-factor structure of visual and kinesthetic imagery ability was supported. Consistent with results from the MIQ-R (16), the participants scored higher on the visual than the kinesthetic subscale on the MIQ-RS. In general, athletes tend to be able to perform visual imagery more easily than kinesthetic imagery; this may be because they have more exposure to visual images such as watching video of themselves performing a skill or watching a teammate or their coaches demonstrate a skill, thereby reinforcing a visual image. This may have implications for practitioners encouraging individuals to begin engaging in imagery; it may be easier to first learn to use visual images and later incorporate kinesthetic images.

Validation Support for Modified Imagery Ability Measure

The validity of the MIQ-RS was examined through CFA; a two-factor (visual and kinesthetic) model of movement imagery ability was supported. The reliability of the MIQ-RS was examined in several ways. First, acceptable internal consistency shows the individual items hold together for each subscale. Second, administering the questionnaires on two occasions (test–retest reliability) demonstrated that the tool was stable over a 1-week interval. Third, using ICC to examine the reliability of the individual items of the MIQ-RS over time produced adequate values.

The participants' scores on the MIQ-RS were compared to their scores on the MIQ-R. Scores on both the visual and kinesthetic subscales of the MIQ-RS were strongly correlated to those on the MIQ-R, suggesting the measurement tools are assessing similar imagery ability constructs. Assessing the validity and reliability of the MIQ-RS with an athletic population allows for comparison of the MIQ-RS to the MIQ-R, an instrument demonstrated to be psychometrically sound for an athletic population, and adds confidence for the utility of the MIQ-RS.

It is important to assess imagery ability prior to implementing an imagery intervention for stroke rehabilitation patients as their ability to image may be compromised by the location and scope of the stroke (10). The MIQ has been successfully used as a screening tool for selecting participants to take part in imagery interventions for stroke patients (24,25). Page and colleagues (24) conducted an innovative alternative imagery intervention

with acute stroke patients and potential participants were excluded if they scored less than 25 on the MIQ, this was deemed evidence the individual was unable to image. As described earlier, given the limitations of the MIQ for use with people with limited mobility and the nature of movement impairment resulting from stroke, the MIQ may be restricted in its utility for this population. The modification of the MIQ-RS to be suitable for people with restricted mobility may make it a more useful tool to assess the imagery ability of individuals undergoing stroke rehabilitation.

As the intention of developing the MIQ-RS was to assess the movement imagery ability of populations with movement limitations, the next step in the assessment of the MIQ-RS is to administer the questionnaire to elderly populations who may have diminished cognitive skill and people with sensory and/or movement impairments such as stroke patients (data currently being collected in the authors' lab). The validity and reliability of the MIQ-RS with these populations can then be examined. If the MIQ-RS is found to be valid and reliable for patient populations, then it may be used for a variety of purposes such as examining the relationship of movement imagery ability to the quality with which rehabilitation exercises are completed. Additionally, the MIQ-RS may be used to screen patients in studies testing the efficacy of various intervention programs using mental imagery to improve usual and customary therapeutic intervention. Practitioners may also use the MIQ-RS to screen their patients prior to recommending imagery as a complementary and alternative therapy to a physical intervention designed to improve recovery of motor function in a sports medicine or clinical setting.

Acknowledgement

References

1. Hall C, Buckolz E, Fishburne GJ. Imagery and the acquisition of motor skills. *Can J Sport Sci* 1992;17:19–27.
2. Ryan ED, Simons J. Cognitive demand, imagery, and frequency of mental practice as factors influencing the acquisition of motor skills. *J Sport Psychol* 1981;3:35–45.
3. Salmon J, Hall C, Haslam I. The use of imagery by soccer players. *J Applied Sport Psychol* 1994;6:116–33.
4. White KD, Ashton R, Lewis S. Learning a complex skill: effects of mental practice, physical practice, and imagery ability. *Int J Sport Psychol* 1979;10:71–8.
5. Brewer BW, Helledy KI. Off (to) the deep end: psychological skills training and water running. *Appl Res CoachingAthletics Annu* 1998;13:99–118.
6. Fox B. Cognitive and motivational functions of imagery during injury rehabilitation and their relation to practice return affect. *J Sport Exercise Psychol* 2004;26:S74.
7. Behm DG. Debilitation to adaptation. *J Strength Cond Res* 1993;7:65–75.
8. Newsom J, Knight P, Balnave R. Use of mental imagery to limit strength loss after immobilization. *J Sport Rehabil* 2003;12:249–58.

9. Williams JG, Odley JL, Callaghan M. Motor imagery boosts proprioceptive neuromuscular facilitation in the attainment and retention of range-of-motion at the hip joint. *J Sport Sci Med* 2004;3:160–6.

10. Sharma N, Pomeroy VM, Baron J. Motor imagery a backdoor to the motor system after stroke? *Stroke* 2006;37:1941–52.

11. Goldstein MS, Brown ER, Ballard-Barbash R, Morgenstern H, Bastani R, Lee J, et al. The use of complementary and alternative medicine among California adults with and without cancer. *Evid-based Compl Altern Med* 2005;2:557–65.

12. Milne M, Hall C, Forwell L. Self-efficacy, imagery use, and adherence to rehabilitation by injured athletes. *J Sport Rehabil* 2005;14:150–67.

13. Hall CR. Imagery in sport and exercise. In: Singer RN, Hausenblas HA, Janelle CM (eds). *Handbook of Sport Psychology*, 2nd edn. New York: John Wiley & Sons, 2001, 529–49.

14. Rodgers W, Hall C, Buckolz E. The effect of an imagery training program on imagery ability, imagery use, and figure skating performance. *J Appl Sport Psychol* 1991;3:109–25.

15. Hall CR, Pongrac J, Buckloz E. The measurement of imagery ability. *Hum Mov Sci* 1985;4:107–18.

16. Hall CR, Martin KA. Measuring movement imagery abilities: a revision of the Movement Imagery Questionnaire. *J Ment Imagery* 1997;21:143–54.

17. Goss S, Hall C, Buckolz E, Fishburne G. Imagery ability and the acquisition and retention of movements. *Memory and Cognition* 1986;14:469–77.

18. Gregg M, Hall C, Nederhof E. The imagery ability, imagery use, and performance relationship. *The Sport Psychologist* 2005;19:93–9.

19. Atienza F, Balaguer I, Garcia-Merita MA. Factor analysis and reliability of the Movement Imagery Questionnaire. *Percept Mot Skills* 1994;78:1323–8.

20. Malouin F, Richards CL, Jackson PL, Lafleur MF, Durand A, Doyon J. The Kinesthetic and Visual Imagery Questionnaire (KVIQ) for assessing motor imagery in persons with physical disabilities: a reliability and construct validity study. *J Neurol Phys Ther* 2007;31:20–9.

21. Abma CL, Fry MD, Li Y, Reylea C. Differences in imagery content and imagery ability between high and low confident track and field athletes. *J Appl Sport Psychol* 2002;14:67–75.

22. Monsma EV, Overby LY. Competitive anxiety and imagery in ballet dance auditions. *J Dance Med Sci* 2004;8:156–65.

23. Braun SM, Beurskens AJ, Borm PJ, Schack T, Wade DT. The effects of mental practice in stroke rehabilitation: a systematic review. *Arch Phys Med Rehabil* 2006;87:842–52.

24. Page SJ, Levine P, Sisto SA, Johnston MV. A randomized efficacy and feasibility study of imagery in acute stroke. *Clin Rehabil* 2001;15:233–40.

25. Page SJ, Levine P, Sisto SA, Johnston MV. Mental practice combined with physical practice for upper-limb motor deficit in subacute stroke. *Phys Ther* 2001;81:1455–62.

26. Crosbie JH, McDonough SM, Gilmore DH, Wiggam MI. The adjunctive role of mental practice in the rehabilitation of the upper limb after hemiplegic stroke: a pilot study. *Clin Rehabil* 2004;18:60–8.

27. Liu KP, Chan CC, Lee TM, Hui-Chan CW. Mental imagery for relearning of people after brain injury. *Brain Inj* 2004;18:1163–72.

28. Dickstein R, Dunsky A, Marcovitz E. Motor imagery for gait rehabilitation in post-stroke hemiparesis. *Phys Ther* 2004;84:1167–77.

29. Martin KA, Moritz SE, Hall CR. Imagery use in sport: a literature review and applied model. *The Sport Psychologist* 1999;10:245–68.

30. Jackson PL, Doyon J, Richards C, Malouin F. The efficacy of combined physical and mental practice in the learning of a foot-sequence task after stroke: a case report. *Neurorehabil Neural Repair* 2004;18:106–11.

31. Lorant J, Nicolas A. Validation de la traduction francaise du Movement Imagery Questionnaire-Revised (MIQ-R). *Science Motricite* 2004;53:57–68.

32. Schmidt RA, Lee TD. *Motor Control and Learning: A Behavioral Emphasis*. Champaign, IL: Human Kinetics, 1999.

33. Winstein C. Designing practice for motor learning: clinical impressions. In: Lister M (ed.) *Contemporary Management of Motor Control Problems: Proceedings of the II Step Conference*. Alexandria, VA: Foundation for Physical Therapy, 1991.

34. Goss S, Hall C, Buckolz E, Fishburne G. Imagery ability and the acquisition and retention of movements. *Memory Cogn* 1986;14:469–77.

35. Field A. *Discovering Statistics Using SPSS*, 2nd edn. London: Sage Publications, 2005.

36. Kelloway EK. *Using LISREL for Structural Equation Modelling-A Researcher's Guide*. Thousand Oaks, CA: Sage, 1998.

37. West SG, Finch JF, Curran PJ. Structural equation models with nonnormal variables: problems and remedies. In: Hoyle RH (ed). *Structural Equation Modeling: Concepts, Issues, and Applications*. Thousand Oaks, CA: Sage, 1995, 56–75.

38. Kline P. *The Handbook of Psychological Testing*, 2nd edn. London: Routledge, 1999.

39. Thomas JR, Nelson JK. *Research Methods in Physical Activity*, 4th edn. Champaign, IL: Human Kinetics, 2001.

Appendix

MIQ-RS

This questionnaire concerns two ways of mentally performing movements that are used by some people more than by others, and are more applicable to some types of movements than others. The first is attempting to form a visual image or picture of a movement in your mind. The second is attempting to feel what performing a movement is like without actually doing the movement. You are requested to do both of these mental tasks for a variety of movements in this questionnaire, and then rate how easy/difficult you found the tasks to be. The ratings that you give are not designed to assess the goodness or badness of the way you perform these mental tasks. They are attempts to discover the capacity individuals show for performing these tasks for different movements. There are no right or wrong ratings or some ratings that are better than others.

Each of the following statements describes a particular action or movement. Read each statement carefully and then actually perform the movement as described. Only perform the movement a single time. Return to the starting position for the movement just as if you were going to perform the action a second time. Then, depending on which of the following you are asked to do, either (i) form as clear and vivid a visual image as possible of the movement just performed, or (ii) attempt to feel yourself making the movement just performed without actually doing it.

After you have completed the mental task required, rate the ease/difficulty with which you were able to do the task. Take your rating from the following scales.

Rating scales:

Visual Imagery Scale

1	2	3	4	5	6	7
Very hard to see	Hard to see	Somewhat hard to see	Neutral (not easy not hard)	Somewhat easy to see	Easy to see	Very easy to see

Kinesthetic Imagery Scale

1	2	3	4	5	6	7
Very hard to feel	Hard to feel	Somewhat hard to feel	Neutral (not easy not hard)	Somewhat easy to feel	Easy to feel	Very easy to feel

Be as accurate as possible and take as long as you feel necessary to arrive at the proper rating for each movement. You may choose the same rating for any number of movements "seen" or "felt" and it is not necessary to utilize the entire length of the scale.

1. Starting Position: Stand with your feet and legs together and your arms at your sides.

   Action: Raise your one knee as high as possible so that you are standing on one leg with your other leg flexed (bent) at the knee. Now lower your leg so that you are again standing on two feet.

   Mental task: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

1	2	3	4	5	6	7
Very hard to feel	Hard to feel	Somewhat hard to feel	Neutral (not easy not hard)	Somewhat easy to feel	Easy to feel	Very easy to feel

   Rating:_____

2. Starting Position: While sitting, put your hand on your lap and make a fist.

   Action: Raise your hand above your head until your arm is fully extended, keeping your fingers in a fist. Next, lower your hand back to your lap while maintaining a fist.

   Mental task: Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.

1	2	3	4	5	6	7
Very hard to see	Hard to see	Somewhat hard to see	Neutral (not easy not hard)	Somewhat easy to see	Easy to see	Very easy to see

   Rating:_____

3. Starting Position: Extend your arm straight out to your side so that it is parallel to the ground, with your fingers extended and your palm down.

   Action: Move your arm forward until it is directly in front of your body (still parallel to the ground). Keep your arm extended during the movement and make the movement slowly. Now move your arm back to the starting position, straight out to your side.

   Mental task: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

1	2	3	4	5	6	7
Very hard to feel	Hard to feel	Somewhat hard to feel	Neutral (not easy not hard)	Somewhat easy to feel	Easy to feel	Very easy to feel

   Rating:_____

4. Starting Position: Stand with your arms fully extended above your head.

   Action: Slowly bend forward at the waist and try and touch your toes with your fingertips. Now return to the starting position, standing erect with your arms extended above your head.

   Mental task: Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.

1	2	3	4	5	6	7
Very hard to see	Hard to see	Somewhat hard to see	Neutral (not easy not hard)	Somewhat easy to see	Easy to see	Very easy to see

   Rating:_____

5. Starting Position: Put your hand in front of you about shoulder height as if you are about to push open a swinging door. Your fingers should be pointing upwards.

Action: Extend your arm fully as if you are pushing open the door, keeping your fingers pointing upwards. Now let the swinging door close by returning your hand and arm to the starting position.

Mental task: Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.

1	2	3	4	5	6	7
Very hard to see	Hard to see	Somewhat hard to see	Neutral (not easy not hard)	Somewhat easy to see	Easy to see	Very easy to see

Rating:_____

6. Starting Position: While sitting, put your hand in your lap. Pretend you see a drinking glass on a table directly in front of you.

Action: Reach forward, grasp the glass and lift it slightly off the table. Now place it back on the table and return your hand to your lap.

Mental task: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

1	2	3	4	5	6	7
Very hard to feel	Hard to feel	Somewhat hard to feel	Neutral (not easy not hard)	Somewhat easy to feel	Easy to feel	Very easy to feel

Rating:_____

7. Starting Position: Your hand is at your side. Pretend there is a door in front of you that is closed.

Action: Reach forward, grasp the door handle and pull open the door. Now gently shut the door, let go of the door handle and return your arm to your side.

Mental task: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty

with which you were able to do this mental task.

1	2	3	4	5	6	7
Very hard to feel	Hard to feel	Somewhat hard to feel	Neutral (not easy not hard)	Somewhat easy to feel	Easy to feel	Very easy to feel

Rating:_____

8. Starting Position: Stand with your feet and legs together and your arms at your sides.

Action: Raise your one knee as high as possible so that you are standing on one leg with your other leg flexed (bent) at the knee. Now lower your leg so that you are again standing on two feet.

Mental task: Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.

1	2	3	4	5	6	7
Very hard to see	Hard to see	Somewhat hard to see	Neutral (not easy not hard)	Somewhat easy to see	Easy to see	Very easy to see

Rating:_____

9. Starting Position: While sitting, put your hand on your lap and make a fist.

Action: Raise your hand above your head until your arm is fully extended, keeping your fingers in a fist. Next, lower your hand back to your lap while maintaining a fist.

Mental task: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

1	2	3	4	5	6	7
Very hard to feel	Hard to feel	Somewhat hard to feel	Neutral (not easy not hard)	Somewhat easy to feel	Easy to feel	Very easy to feel

Rating:_____

10. Starting Position: Extend your arm straight out to your side so that it is parallel to the ground, with your fingers extended and your palm down.

Action: Move your arm forward until it is directly in front of your body (still parallel to the ground). Keep your arm extended during the movement and make the movement slowly. Now move your arm back to the starting position, straight out to your side.

Mental task: Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.

1	2	3	4	5	6	7
Very hard to see	Hard to see	Somewhat hard to see	Neutral (not easy not hard)	Somewhat easy to see	Easy to see	Very easy to see

Rating:_____

11. Starting Position: Stand with your arms fully extended above your head.

Action: Slowly bend forward at the waist and try and touch your toes with your fingertips. Now return to the starting position, standing erect with your arms extended above your head.

Mental task: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

1	2	3	4	5	6	7
Very hard to feel	Hard to feel	Somewhat hard to feel	Neutral (not easy not hard)	Somewhat easy to feel	Easy to feel	Very easy to feel

Rating:_____

12. Starting Position: Put your hand in front of you about shoulder height as if you are about to push open a swinging door. Your fingers should be pointing upwards.

Action: Extend your arm fully as if you are pushing open the door, keeping your fingers pointing upwards. Now let the swinging door close by returning your hand and arm to the starting position.

Mental task: Assume the starting position. Attempt to feel yourself making the movement just performed without actually doing it. Now rate the ease/difficulty with which you were able to do this mental task.

1	2	3	4	5	6	7
Very hard to feel	Hard to feel	Somewhat hard to feel	Neutral (not easy not hard)	Somewhat easy to feel	Easy to feel	Very easy to feel

Rating:_____

13. Starting Position: While sitting, put your hand in your lap. Pretend you see a drinking glass on a table directly in front of you.

Action: Reach forward, grasp the glass and lift it slightly off the table. Now place it back on the table and return your hand to your lap.

Mental Task: Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.

1	2	3	4	5	6	7
Very hard to see	Hard to see	Somewhat to see	Neutral (not easy not hard)	Somewhat easy to see	Easy to see	Very easy to see

Rating:_____

14. Starting Position: Your hand is at your side. Pretend there is a door in front of you that is closed.

Action: Reach forward, grasp the door handle and pull open the door. Now gently shut the door, let go of the door handle and return your arm to your side.

Mental Task: Assume the starting position. Attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. Now rate the ease/difficulty with which you were able to do this mental task.

1	2	3	4	5	6	7
Very hard to see	Hard to see	Somewhat to see	Neutral (not easy not hard)	Somewhat easy to see	Easy to see	Very easy to see

Rating:_____