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The Orthopaedic Rehabilitation of balance: An experimental study on the role of mental imagery and emotional variables

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Abstract: Mental Imagery (i.e., processing of objects' properties and spatial relations, including the ability of mentally rotating and manipulating objects in the space), is relevant for movement and its development, and particularly for rehabilitation of motor skills. Few studies aimed at assessing the efficacy of imagery training used objective scores of Mental Imagery skills, preferring self-evaluations of these abilities reported by the subjects themselves. The aim of the paper was to explore the relevance of Mental Imagery, assessed by objective tests, in predicting the improvement of balance skills, after a standard rehabilitative training in orthopaedic settings; taking into account also emotional variables as anxiety and depression. A controlled study was conducted assessing the changes in balance skills after rehabilitative training. The sample was composed of 30 orthopaedic inpatients (females 66.7%, age range 47-91 years). To measure the dependent variable for pre-post assessment, B-scale from *Performance-oriented mobility assessment* test (POMA) was used. Independent variables were measured using *Mental Imagery Test*, *Mini-Mental State Examination*,

Hamilton Depression Rating Scale and *Hamilton Anxiety Rating Scales*. The best predictor of improvement in balance after rehabilitation is the Mental Imagery test, followed by age and mental efficiency. Anxiety predicts negatively the improvement, while education and depression appear to influence less the rehabilitation process.
In conclusion, the study demonstrates that mental imagery is relevant in helping balance rehabilitation. A training of this function could be essential for clinical practice; the trainers should assess preliminarily the subject's attitude and ability to use mental imagery, with the aim of optimizing the rehabilitative process.

Key words: Orthopaedic Rehabilitation, Balance, Mental Imagery, Anxiety, Depression.

INTRODUCTION

Balance is a critical component for performing basic and advanced activities of daily living; it is predictive of mobility, and of the risk of falling in older people. It may be impaired after diseases or injuries (Sibley, Mochizuki, Lakhani, &McIlroy, 2014). Balance involves the correct functioning of eyes, ears, and muscles, coordinated by the brain; it involves somato-sensory systems, including the body's sense of being located in space (i.e., proprioception) and recovery of balance after orthopaedic interventions is an essential target of assessment in rehabilitation (O'Sullivan & Schmitz, 2007; Brent Brotzman, & Manske, 2011). But these interventions are often lacking in efficacy (Howe, Rochester, Neil, Skelton, & Ballinger, 2011). Effective evidence-based protocols for maximizing return to functional motor skills, following common physical injuries or post-surgical conditions, should include also cognitive variables, such as visual perception, memory, and visualization.
A variable relevant for movement and its development is Mental Imagery, intended as reproduction – and original interpretation, if requested - of cognitive contents not immediately present in the actual sensorial perception, using working memory and rehearsal (Kosslyn, 1980; 2006). Processing of both objects properties (shape, color) and spatial relations, i.e. the ability of mentally rotating and manipulating objects in the space, are relevant for mental imagery skills (Kozhevnikov, Kosslyn, & Shephard, 2005). Different studies have shown the useful effects of mental practice in

orthopedic rehabilitation, e.g., in preventing loss of hand function associated with mid-term immobilization (Frenkel, Herzig, Gebhard, Mayer, Becker, & Einsiedel, 2014). Yao, Ranganathan, Allexandre, Siemionow, and Yue (2013) suggest that training by internal imagery of forceful muscle contractions is effective in improving voluntary muscle strength and led to greater muscle output. Another study (Schott & Korbus, 2014) was done to control for the ability to perform and control a mental image of a movement, which is essential for preventing functional loss during immobilization after fractures in elderly patients.

The importance of mental images in training and motor practice has been affirmed (e.g., Williams, Odley, Callaghan, 2004; Stenekes, Geertzen, Nicolai, De Jong, & Mulder, 2009) since the earliest neurophysiological findings applied to different domains of rehabilitation (neurological and orthopaedic), sports etc. (e.g., Jeannerod, 1994).

Jackson, Lafleur, Malouin, Richards and Doyon (2001) proposed a model to emphasize the role of motor imagery as an essential process of mental practice, useful in neurological rehabilitation.

Imagery is effective for learning and performance in motor tasks as it provides information not otherwise available to the subject (Cumming & Ste-Marie, 2001). The training of cognitive imagination is used to facilitate the recovery and to execute, at the best, the rehabilitative exercises. It can contribute to control pain, predict the return to activity, and increase the positive attitude toward the rehabilitation. (Cupal, Brewer, 2001; Christakou, Zervas, Lavallee, 2007). In sport rehabilitation, both visual and kinaesthetic images are used, tailored to the specific characteristics of the accident and the injured person (Driediger, Hall, Callow, 2006). But few studies used objective scores of Mental Imagery skills for evaluating rehabilitative processes, preferring self-evaluations of these abilities reported by the subjects themselves, while the reliability of self-report with respect to actual abilities is highly questionable.

The aim of our study was to explore the relevance of Mental Imagery, measured by cognitive tasks, in predicting the improvement of balance skills after a standard rehabilitative training in orthopaedic settings; taking into account also emotional variables such as anxiety and depression.

We chosen the balance as specific variable to assess in our study, considering that the role of imagery on general motion is already well demonstrated: e.g., many studies found that real and imagined movements as functionally similar (Decety, Jeannerod, & Prablanc, 1989; Calmels, Fournier, 2001; Calmels, Holmes, Lopez, & Naman, 2006; Reeds, 2002;

Guillot & Collet, 2005); in a neuropsychological perspective, the primary motor cortex M1 is active during the production of motor images. “Covert stages of action … include not only intending actions that will eventually be executed, but also imagining actions ... The function of this process of simulation would be not only to shape the motor system in anticipation to execution, but also to provide the self with information on the feasibility and the meaning of potential actions (Jeannerod, 2001, p. 103).
If the role of imagery in motion is well known, the specific influence of balance was less studied.
The role of emotional variables for the rehabilitative process is underestimated in rehabilitative interventions; few studies focus these variables, e.g. Ayers, Franklin and Ring (2013) who showed that, despite the success of orthopaedic procedures, functional improvement after surgery varies widely, due to poor emotional health such as anxiety, depression, poor coping skills, and poor social support. The authors state that “the emotional health of the patient influences the outcome of many common orthopaedic surgeries” (p. 165).
We hypothesized that individuals with high scores in tests for Anxiety and Depression also show a worse rehabilitative outcome, related also to the mental imagery ability.

MATERIALS AND METHODS

A controlled study was conducted, testing the hypothesis that mental imagery is a predictor of improvements in balance after an orthopaedic treatment, associated with general mental efficiency and anxiety and depression as emotional variables.
Thirty orthopaedic inpatients (females 66.7%) in the same intensive post-acute rehabilitative structure were included in the study. All the subjects were recruited after a week from the admission in the structure, consecutively for five months. They were selected with exclusion of relevant neurological impairments or psychiatric comorbidities, and/or very low scores in the test measuring mental deterioration (MMSE<20).
The age range of the sample was 47-91 yrs, mean age 70.30, standard deviation 10.73. Education years ranged from 2 to 18, with mean = 7.90 and standard deviation = 4.17.

Diagnosis was: chirurgical implants 70.0%, fractures 22.3%, other orthopaedic problems 6.7%; the 66.7% of the sample had underwent previous orthopaedic interventions of the same nature.
Assessment was made before and after a standard period of rehabilitative treatment lasting one month, with one-hour sessions twice in a day. Interventions involved exercises regarding mainly co-ordination and functional movements, muscle strengthening, and other stimulations of balance. The treatment was conducted by expert physiotherapists trained in motor rehabilitation, following a standard protocol.
All subjects gave informed consensus to participate in the study, and approved by the ethical committee of the structure.
To assess dependent variable, i.e. the changes in balance skills after rehabilitative training, the appropriate scale from *Performance-oriented mobility assessment* (POMA) test was used. This test (Tinetti, 1986) is a task-oriented test that measures static and dynamic balance and gait abilities by an ordinal scale from 0 (most impairment) to 2 (total independence).
The B-scale (Balance) can be used separately to assess this variable (Mitchell, Newton, 2006). The reliability of this scale is satisfactory, .93 in older adults (Faber, Bosscher, Van Wieringen, 2006).
To measure independent variables, the following psychometric tests were used.
1. The *Mental Imagery Test* (MIT), a battery composed of eight tasks, derived from different sources retrieved in mental imagery literature, measuring mental imagery skills, involving generation, maintenance and manipulation of different categories of images.
Visualizing letters. The subjects are requested, without seeing the stimuli and using only imagination, to say which upper-case letters have curved parts (e.g., A, P, or R; not L, M, or N).
Brooks 'F' Test. Using their imagination, the subjects are asked to walk along the contour of a large upper-case letter F previously viewed for 30 seconds on a printed card. The subject is asked to say whether the edges encountered when moving from the lower left corner in a counter-clockwise direction are external or internal.
Clock. The task requires imagining a clock with hands indicating 10 past 10, then imagining the clock reflected in a mirror and saying what time will be shown by the reflected clock after ten minutes.
Cube. The picture of a large cube is shown for 30 seconds; it is composed of nine small cubes per face (3 x 3), and the external faces are colored. After the stimulus is removed, the subject is asked to state how many small cubes

have three external (colored) faces, how many have two, how many one or none.
Subtraction of parts. A digital display with the number 88 composed of small segments is shown for 10 seconds. Then, another digital display with selected segments of a two-digit number is shown for 10 seconds. The subject is asked to imagine what two-digit number will remain after subtracting the parts of the new figure from the figure with all digits seen previously.
Mental exploration of a map. The subject is presented with a map of an island, with a house, a church, a lake, and a woods located on it. The instructions ask to look with attention at the map, fixing the distances among the elements located. After the map is removed, the subject is asked to answer four questions about the comparative distance between couples of the previously seen elements.
Imagined paths. Subject is asked to visualize a small ball moving in different directions, following a suggested path in the imagined space, and saying if at the end of the route the ball will end up above or below the starting point, or at the same level.
Mental representation of shapes of objects. The subject hears the names of twenty concrete objects (e.g. bottle, pizza, candle, tower, bed), and is asked to visualize them and decide if the object has a taller or larger shape.
A total score is obtained summing up the scores of single subtests. Cronbach's *alpha* for the whole imagery score is .78 (Di Nuovo, Castellano, Guarnera, 2014).
2. *Mini-Mental State Examination (*Folstein, Folstein, & McHugh, 1975), a 30-item test widely used in clinical practice for screening of mental efficiency or cognitive impairment. It's a test easy and quick to administrate, reliable to determinate the degree of cognitive deterioration. Seven different cognitive areas are assessed: temporal and spatial orientation, attention and calculation, memory, language and motor skills (constructional praxis) answering to complex commands. Corrections both for age and education are provided.
3. *Hamilton Depression Rating Scale* (HDRS) (Hamilton, 1960), is a widely used questionnaire devised to assess mood, feelings of guilt, suicide ideation, insomnia, agitation or retardation, anxiety, weight loss, and somatic symptoms, providing an overall score of depression. Each item is rated on a 5-point scale: absent (0), mild (1), moderate (2), severe (3) and very severe (4). The 29-item version was used (Williams, Link, Rosenthal, Terman, 1988).

4. *Hamilton Anxiety Rating Scales* (HAM-A) (Hamilton, 1959), measures through five-point scales the severity of anxious moods, tension, fears, cognitive and somatic symptoms, like as insomnia, somatic complaints and behavior during the interview. The scale consists of 14 items, each rated on a 5-point scale: absent (0), mild (1), moderate (2), severe (3), very severe (4). The range of the score can be comprised from 0 to 56; a total score over the cut-off of 18 is considered pathological.

RESULTS

Zero-order correlations (Pearson's product-moment coefficients) are shown in table 1, along with means and standard deviations for all variables.

Table 1 – Means, standard deviations and correlations with Mental Imagery scores.

	Mean	*St.dev.*	*Pearson r with Mental Imagery*
			M=51.57, SD=12.53
Age	70.30	10.73	-0.64*
MMSE (corrected score)	26.27	2.62	0.35*
Education	7.90	4.17	0.30*
Depression	13.63	5.95	-0.13
Anxiety	17.53	5.65	-0.21
Balance (pre-post gain)	8.23	2.97	0.34*

p<.05

Significant relations are reported between Mental Imagery and both years of education and mental efficiency measured by MMSE. Correlations with anxiety and depression are, as expected, negative since non statistically significant (-0.21 and -0.13, respectively).

It is relevant for our hypothesis the positive and significant relations between mental Imagery and the gain in the balance score after the treatment. In a causal approach, a multiple correlation was performed to evaluate what variables more effectively predict the pre-post difference in balance after treatment (table 2).

Table 2 – Multiple regression analysis.

Effect	*Std. Coefficient*	*t*	*p-value*
Mental Imagery	0.59	2.00	0.06
Age	0.35	0.96	0.35
MMSE (corrected score)	0.26	0.47	0.64
Education	-0.02	-0.10	0.92
Depression	0.02	0.06	0.95
Anxiety	-0.25	-0.76	0.45

Note. Dependent variable: Improvement in Balance. Predictors: Mental Imagery, Age, MMSE, Education, Depression, Anxiety (Multiple R=0.42).

Improvement in balance is predicted by a higher score in Mental Imagery test, which is the best predictor, followed by age and mental efficiency (MMSE, after correcting for age and schooling).

Anxiety predicts negatively the improvement: i.e., more anxiety, less gain is expected. Education and depression appear to influence less the rehabilitation process.

In most cases the values found in the regression analysis are not statistically significant, due to the small size of the sample, but the effect sizes (i.e., regression coefficients) could be considered relevant.

A Discriminant Analysis was conducted to assess the efficacy of the considered psychological variables in differentiating improved versus not improved patients, divided by the median of the gain scores distribution. The contribution of each variable to the differentiation was also evaluated.

The classification matrix demonstrated that the model of discriminant analysis classifies the 'not improved' group with a correctness of 79%, while 63% for the 'improved' group. The total misclassification was 30%. Canonical correlation was 0.43.

Also in this analysis, the contribution of Mental Imagery (F-to-remove = 0.94, the higher value in the analysis) is similar to MMSE score (0.93), confirming the importance of this variable in determining the change after the rehabilitative treatment.

None of the other variables (diagnosis: implants, fractures; previous orthopaedic interventions) showed significant relations with the improvement after the treatment.

DISCUSSION

In our study regarding orthopaedic patients in rehabilitation mental imagery, measured by appropriate cognitive tasks, appears to be inversely related with age, while positively with years of education and mental efficiency. A negative but not statistically significant correlation was found with anxiety and depression.
As hypothesized, mental imagery is a good predictor of pre-post difference in balance after orthopaedic treatment. Imagery skills show an influence superior to mental efficiency as measured by MMSE corrected score. Anxiety negatively influences the improvement, more than depression.
These results using objective scores of Mental Imagery skills, confirm the conclusions of other studies reported in literature, based mainly on self-evaluations of these abilities.
A main limitation in the composition of the sample is the heterogeneity of the participants. Differences regarded both physical and psychic sufferance with regard to the kind of pathology and the age of onset.
Considering that Mental Imagery is a relevant variable in predicting improvements in balance after an orthopaedic treatment, it is possible to assume that a training of this function may help the rehabilitation process, with particular reference to balance.
Specific guidelines are needed in planning this training, based on scientific criteria more than on pure practice (Bovend'eerdt, Dawes, Sackley, & Wade, 2012; Schott, Frenkel, Korbus, & Francis, 2013).

CONCLUSION

The athletic trainers and physical therapists must be properly sensitized and trained on the effectiveness of mental imagery and on the usefulness of self-monitoring to increase adherence to treatment and accelerate recovery from injury (Hamson-Utley, Martin, & Walters, 2008).
However, it is essential that the trainers and rehabilitators assess preliminarily the subject's attitude and ability to use visualization and mental imagery (Sordoni, Hall, & Forwell, 2000), planning to implement it if lacking in the patient who undergoes rehabilitation.

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