Motricidade
2011, vol. **7**, n. **3**, pp. **37-43**

ISSN 1646−107X

Motor imagery as a tool for motor skill training in children

A imaginação motora como instrumento de treino das habilidades motoras em crianças

A. Doussoulin, L. Rehbein

ABSTRACT

The present study aimed at checking the effectiveness of motor imagery on children's motor training. A total of 64 students aged 9 to 10 years, enrolled in three different 4th grade classes, participated in the study. Subjects in the modeling group were asked to view the video recording of an expert performing the task; those in the physical practice group were trained through the actual execution of the task; and subjects in the imagery group, were trained based solely on motor imagery. The task consisted of throwing a ball towards a target. Performance of subjects before and after training was assessed. Results showed improvements for all three groups. However, motor imagery and modeling groups obtained significantly higher mean scores than the physical practice group. Results are discussed in terms of the potential of motor imagery as a training tool in children.
Keywords: motor imagery, motor skill, motor learning

RESUMO

O presente estudo teve como objectivo investigar a eficácia da imaginação motora na formação motora em crianças. Um total de 64 estudantes entre 9 e 10 anos, inscritos em três diferentes turmas do 4º ano de escolaridade, participaram no estudo. Foi solicitado às pessoas do grupo modelagem que vissem a gravação de um vídeo de um *expert* realizando a tarefa; aqueles do grupo de prática física foram treinados através da execução real da tarefa; os sujeitos do grupo imaginação receberam treino baseado unicamente na imaginação motora. A tarefa consistiu em jogar uma bola em direcção a um alvo. O comportamento dos sujeitos foi avaliado antes e depois do treino. Os três grupos mostraram melhoria em seus resultados; porém, o grupo de imaginação motora e o grupo modelagem obtiveram pontuações significativamente mais altas que o grupo de prática física. Os resultados são discutidos em termos do potencial da imaginação motora como uma ferramenta de treino em crianças.
Palavras-chave: imaginação motora, habilidade motora, aprendizagem motora

Submetido: 25.07.2010 | Aceite: 24.10.2010

Arlette Doussoulin e *Lucio Rehbein*. Facultad de Medicina, Universidad de La Frontera, Chile.
Endereço para correspondência: Arlette Doussoulin, Departamento de Pediatría y Cirugía Infantil, Facultad de Medicina, Universidad de La Frontera, Campus Andres Bello, Av. Francisco Salazar 01145, Temuco, Chile.
E-mail: doussoul@ufro.cl

The execution of any new motor skill always depends on learning; more specifically, it requires the accumulation of new knowledge to be retained in procedural memory as a result of practice. Thus, new motor skills are generated on the basis of previously learned actions (Oña, 1998). Early childhood is a critical period for psychomotor development, since many basic motor capabilities are integrated with other more complex abilities. Development of these abilities during early childhood affects the ease of achieving acceptable performance on more complex motor tasks during adolescence and adulthood (Gómez, 2003). Conversely, adults who have not reached mature ability in basic motor capabilities could have difficulty to successfully participating in recreational and competitive activities that require physical proficiency and motor coordination (McClenaghan & Gallahue, 1998).

Currently, there are different forms of training by means of which learning of a motor skill can be improved. Modeling, or direct demonstration, for example, is one of the most usual forms of giving instruction during the learning of a motor task. By means of modeling, the novice quickly forms herself an idea or cognitive image of the movement to be executed. Modeling has been defined as a cognitive process in which the learner attempts to imitate an observed action or skill performed by another individual (McCullagh, Weiss, & Ross, 1989). A similar technique, also based on the execution of the task by an expert, is the modeling of a motor performance through video recording in lieu of a direct demonstration. This is especially useful when the child needs to visualize the complete set of combined movements required and the instructor cannot demonstrate the task directly (Knapp, 1981).

Both these training procedures stem from Sheffield's (1961) theory of symbolic representation, which states that when a person observes a demonstration of a motor skill, an image is encoded in memory that consists of a sequence of perceptual and symbolic responses, which later will allow an effective execution of the same pattern. According to Bandura (1986), modeling is effective when processes like attention, retention, production, and motivation are present. Attention requires the learner to attend to salient cues of the observed performance provided by the model. Then, the learner must retain these important cues in memory for later attempts of the desired skill without additional modeling. In addition to storing the information in memory, the learner must possess the physical capabilities required to reproduce the modeled act. Finally, the learner must have sufficient desire to emulate the observed performance to produce a modeling effect. Numerous researchers have found modeling to be effective in facilitating learning and performance of motor skills (see McCullagh & Weiss, 2001, for a review).

More recently a new training technique known as mental practice through "motor imagery" has emerged. This technique has been widely used by skilled athletes and in rehabilitation of patients with neurological pathologies (Guillot, Tolleron, & Collet, 2010; Lebon, Collet, & Guillot, 2010; Malouin, Richards, Durand, & Doyon, 2009). Imagery is a cognitive process that has also been found to enhance learning and performance of motor skills (Driskell, Copper, & Moran, 1994; Hall, 2001; Martin, Moritz, & Hall, 1999). Richardson (1969) has defined imagery as "*those quasi-sensory and quasi-perceptual experiences of which we are self-consciously aware and which exist for us in the absence of the stimulus conditions that are known to produce their genuine sensory or perceptual counterparts*" (pp. 2-3). One theoretical framework advanced to explain imagery effects on performance and learning of motor skills is the symbolic learning theory. The symbolic learning theory suggests that the learner creates a "mental blueprint" of the movement patterns into symbolic codes that is encoded in the central nervous system (Roosink & Zijdewind, 2010; Vealey &

Greenleaf, 1998). This cognitive representation or image can be used during imagery to cue the learner on temporal and spatial elements of the skill. The learner rehearses this image, and uses this information to guide and improve the physical performance of the skill (Murphy & Jowdy, 1992). Similar to modeling, the efficacy of imagery has been documented by a large body of scientific evidence (see Driskell et al., 1994; Hall, 2001; Martin et al., 1999 for reviews). Complementary to this evidence, Palmi (1991) noted that training by imagery was more efficient when related to very specific motor tasks; whereas Bohan and Pharmer (1999) considered that imagery was more beneficial during the early stages of development of a motor skill. Taken together, the above reviewed evidence indicates that both modeling, as well as motor imagery have been investigated and contrasted with other training techniques in the juvenile and adult population, and they have been proven to be a an effective tool for training motor skills (SooHoo, Takemoto, & MaCulagh, 2004). However, to our knowledge there is scarce evidence with regards to their effectiveness, particularly in the case of mental imagery, on the performance of an aiming-to-a-target and throwing task, in trainees from younger age groups (Millard, Mahoney & Wardrop, 2001).

The goal of the present investigation was to assess the effectiveness of training based on motor imagery, in comparison to other training techniques, in elementary school children. It was expected that all methods of training would contribute to improved performance on a task of throwing a ball towards a distant target; however, it was expected that participants trained using motor imagery, and those trained through modeling, would have a significantly better performance, as compared with those trained via physical practice alone.

METHODS

Subjects

Participants were 64 students of both sexes aged 9 to 10 years, enrolled in three 4th grade classes, in an urban elementary school from Temuco, Chile.

Students, as well as their parents, signed a written consent for participation in the study. Inclusion required the absence of motor and/or sensory disturbances as far as the students were concerned. In addition to consent, age, sex, and the final grade obtained in previous semester's Physical Education class, were recorded.

Students had been assigned to each class on a first come, first served basis, when they initially enrolled, three and a half years earlier; hence, each class group was considered to be a randomly composed conglomerate that carried no systematic difference vis-à-vis any one from the other two. Consequently, each class was randomly assigned to either one of the treatment conditions, as follows: (i) Students in class "A" (n = 21) were assigned to the Modeling condition, which consisted of watching a video recording of the task being performed by an expert; (ii) Students in class "B" (n = 21) were assigned to the Physical Practice condition, and therefore, trained by the repeated execution of the task; and (iii) Students in class "C" (n = 22) were assigned to the Motor Imagery condition, where they were instructed to mentally (covertly) rehearse the motor execution of the task, after trying it.

Instruments

The measures used as dependent variables were scores of the Standardized Basic and Combined Movements Scale; and distance reached by students on each throw of the ball.

SBCMS (Standardized Basic and Combined Movements Scale). This is an ordinal scale that measures the stage of development of basic, isolated and combined, movements and the control of temporal and spatial aspects of movement, as specified by the physical educational objectives from the officially approved study programs for elementary education in Chile. Its reliability coefficient, by using Cronbach alpha, was .83 (Trujillo, Doddis, & Ibacache, 1999). The scale's maximum possible score is 11, derived from the simple addition of fulfilled criteria, as listed in Table 1.

Table 1
Complete item listing from Standardized Basic and Combined Movements Scale

ITEMS
1. Child runs balancing both arms back and forth with his elbows flexed.
2. Child runs balancing arm movements in alternation with his legs.
3. Child bends his knees while running.
4. Child runs without aggregation of collateral involuntary movements.
5. Child throws, without losing continuity in his sprint.
6. When throwing, the child leans forward onto the foot opposite the throwing arm at the same as displacing his body weight advancing the other foot.
7. When the child throws, he rotates his body in the direction of the thrust.
8. When the child throws, the arm that carries the ball extends itself backwards and then forward and upwards, above the head.
9. The throwing movement is accompanied by successive legs, hip, trunk and shoulder movements.
10. Child throws longitudinally, in direction to the identified target.
11. Child throws without aggregation of collateral involuntary movements.

Note: Scale score is the direct sum of item scores (0 = not fulfilled, 1 = fulfilled)

The motor task evaluated was to run and throw a ball towards a distant target by using the dominant hand. Its main features were as follows: the child ran a distance of 10 meters on a smooth, flat surface, free of obstacles, with a tennis ball in his dominant hand. Upon arrival at a line, the student threw the ball towards a distant target (a clown face) attempting to get as close as possible. The average of two consecutive run-and-throw trials was recorded.

Procedures

During the first session, all children who voluntarily accepted to participate in the study were scored by applying the SBCMS criteria on their performance in the task described. Also, the distance reached by the ball thrown by every participant was recorded. This was taken as their pre-training baseline performance.

Subsequently, six training sessions of 10 trials each were run individually with every subject from each group. Finally, immediately after the sixth training session (60 trials), the SBCMS was applied again, in order to assess the extent of learning achieved on the targeted motor task.

The pre- and post-training assessments were performed by an expert collaborator who was highly experienced in the application of the SBCMS and who ignored the training condition each child was assigned to.

RESULTS

The data obtained from participants in each group on the target task, before and after training, as measured by the SBCMS, are presented in Table 2. These data were submitted to a two-way analysis of variance with repeated measures, obtaining a statistically significant main effect of training ($F_{(1,61)} = 136.81$, $p < .001$); as well as a significant training by groups interaction effect ($F_{(2,61)} = 3.56$, $p < .05$). No main effect for groups was found.

Table 2
Means and standard deviations on SBCMS obtained at initial and final evaluation of performance by participants by groups

Group	Pre-training		Post-training	
	M	*SD*	*M*	*SD*
Modeling (video)	7.71	2.00	9.09	1.67
Physical practice	7.95	1.23	9.90	.91
Motor imagery	7.09	1.57	10.09	1.19

In order to uncover whether the significant interaction effect was due to the performance by a specific group in the study, post hoc analyses were calculated by using Tukey's HSD *a posteriori* test. No significantly different improvement was found for any of the groups.

The data from measures of throwing distance, before and after training, were also submitted to the two-way analysis of variance for repeated measures, resulting in a statistically significant main effect of distance ($F_{(1,61)}$ = 17.94, $p < .001$), but no significant main effect was found for group, nor for interaction effect between distance and group.

A posteriori contrasts by using Turkey´s HSD test showed that the statistically significant main effect was due to the greater distances achieved by subjects from motor imagery group and by those from modeling group on their post training as compared to their pre training performance ($p < .05$).

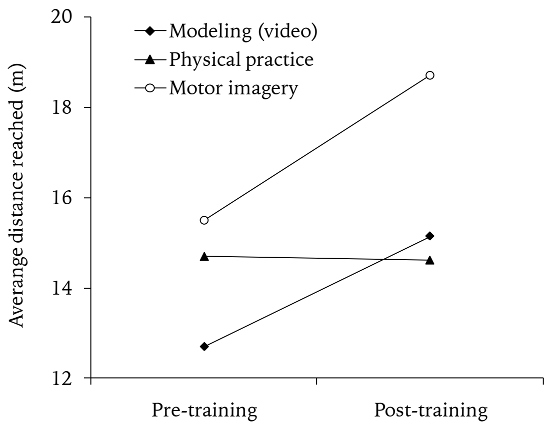

Figure 1. Initial (pre-training) and final (post-training) mean throwing distances reached (meters) by subjects in each of the three groups

DISCUSSION

The main finding of this study was the verification that, in spite that all forms of training being effective in improving the performance of the motor task evaluated in these boys and girls, the training with motor imagery and with modeling were more effective in obtaining a significantly higher final performance than did physical practice alone.

These results would indicate that the mental practice through motor imagery is an effective interventions strategy for learning, or improvement of motor skill in children. This finding is in agreement with previous research which suggests that motor imagery improves the learning of a motor task in adult subjects (Gentili, Han, Schweighofer, & Papaxanthis, 2010; Mulder, Zijlstra, & Hochstenbach, 2004; Toussaint, 2010; Vieilledent, Kosslyn, Berthoz, & Giraudo, 2003; Yaguez, Nagel, & Hoffman, 1998; Yue & Cole, 1992).

Having demonstrated that motor imagery is effective in learning of a motor skill in school children extends the age-range effectiveness for this intervention strategy. Furthermore, if we combine with this result, Bohan and Pharmer's (1999) finding that motor imagery appears more beneficial in the early learning stages of a motor task, imagery turns out to be a doubly effective technique to apply during the development of a motor skill in young children. As it happens, throwing is considered a basic motor ability, as it comprises a combination of movements which are natural to the human being and which develop between 6 and 12 years of age, the same period that encompasses the acquisition and development of the perceptual-motor abilities and the full development of the body scheme in the child (McClenaghan & Gallahue, 1998). As a result of this, the execution and complexity of the task chosen for training in this study should not have generated any stress among the participants.

A fairly unexpected finding in this study was the similarity of results obtained from both imagery and modeling procedures. However, even though research has typically addressed modeling and imagery as separate and distinct processes, several investigators have noted that modeling and imagery are actually quite similar (Druckman & Swets, 1988; Feltz & Landers, 1983; Housner, 1984; McCullagh & Weiss, 2001; Ryan & Simons, 1983; Vogt, 1995). Both of these processes include the use of cognitive representations, rehearsal, and skill execution. During modeling, information about the skill is encoded into a cognitive representation. Likewise, during imagery a cognitive representation or image is recalled from memory. Bandura (1997) posits that modeling involves recalling symbolic codes through imagery or words to enhance learning and retention, suggesting that the cognitive process of modeling and imagery are similar. Both the image and model representations are encoded and rehearsed before actual physical execution of the skill.

In sum, the most interesting conclusion from this study is that motor imagery can have an effect on children between the ages of nine and ten, when learning a skill. The early childhood period is critical for the richness and depth of the subsequent psychomotor development. It is in this manner that motor experiences achieved through play – which children are typically exposed to –, do not vary sufficiently as to acquire or improve the necessary motor abilities to achieve an adequate development, without the aid of planned motor experiences. It would be incorrect to assume that the majority of children develop efficient and mature motor abilities without some sort of training. Hence, the present study supports the use of motor imagery as well as modeling, as possible tools for such training. It remains to be tested whether these procedures, by themselves, or in combination with others, can be still effective in improving performance on more complex and sophisticated motor tasks.

For the future research is important to have a larger sample would permit testing differential between particular groups, such as men or woman, age and race. With regard to evaluation and intervention is important to include validated instruments to permit assess this interventions and develop integrated programs like combination of mental and practical training.

REFERENCES

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W. H. Freeman.

Bohan, M., & Pharmer, J. (1999). When does imagery practice enhances performance on a motor task. *Perceptual and Motor Skills, 88*, 651-658.

Driskell, J., Cooper, C., & Moran, A. (1994). Does mental practice enhance performance? *Journal of Applied Psychology, 79*, 481-491.

Druckman, D., & Swets, J. A. (1988). *Enhancing human performance: Issues, theories and techniques*. Washington, DC: National Academy Press.

Feltz, D. L., & Landers, D. M. (1983). The effects of mental practice on motor skill learning and performance: A meta-analysis. *Journal of Sport Psychology, 5*, 25-57.

Gentili, R., Han, C., Schweighofer, N., & Papaxanthis, C. (2010). Motor learning without doing: Trial-by-trial improvement in motor performance during mental training. *Journal of Neurophysiology, 104*(2), 774-778.

Gómez, H. (2003). *El aprendizaje de las habilidades y esquemas motrices en el niño y el joven*. Barcelona: Ed. Stadium.

Guillot, A., Tolleron, C., & Collet, C. (2010). Does motor imagery enhance stretching and flexibility? *Journal of Sports Science, 28*(3), 291-298.

Hall, C. R. (2001). Imagery in sport and exercise. In R. N. Singer, H. A. Hausenblas, & C. M. Janelle (Eds.), *Handbook of sport psychology* (pp. 550-565). New York: John Wiley & Sons.

Housner, L. D. (1984). The role of imaginal processes in the retention of visually preserved sequential motoric stimuli. *Research Quarterly for Sport and Exercise, 55*(1), 24-31.

Knapp, C. (1981). *La habilidad en el deporte*. Valladolid: Miñon, S.A.

Lebon, F., Collet, C., & Guillot, A. (2010). Benefits of motor imagery training on muscle strength. *Journal of Strength and Conditioning Research, 24*(6), 1680-1687.

Malouin, F., Richards, C., Durand, A., & Doyon, J. (2009). Added value of mental practice combined with a small amount of physical practice on the relearning of rising and sitting post-stroke: A pilot study. *Journal of Neurologic Physical Therapy, 33*(4), 195-202.

Martin, K. A., Moritz, S. E., & Hall, C. R. (1999). Imagery use in sport: A literature review and applied model. *The Sport Psychologist, 13*, 245-268.

McClenaghan, B., & Gallahue, D. (1998). *Movimientos fundamentales, su desarrollo y* *rehabilitación*. México: Editorial Medica Panamericana.

McCullagh, P., & Weiss, M. R. (2001). Modeling: Considerations for motor skill performance and psychological responses. In R. Singer, H. Hausenblas, & C. Janelle (Eds.), *Handbook of sport psychology* (pp. 205-238). New York: Wiley & Sons.

McCullagh, P., Weiss, M. R., & Ross, D. (1989). Modeling considerations in motor skill acquisition and performance: An integrated approach. In K. B. Pandolf (Ed.), *Exercise and sport science reviews* (pp. 475-513). Baltimore: Williams & Wilkins.

Millard, M., Mahoney, C., & Wardrop, J. (2001). A preliminary study of mental and physical practice on the kayak wet exit skill. *Perceptual and Motor Skills, 92*, 977-984.

Mulder, S., Zijlstra, W., & Hochstenbach, J. (2004). The role of motor imagery in learning a totally novel movement. *Experimental Brain Research, 154*, 211-217.

Murphy, S. M., & Jowdy, D. P. (1992). Imagery and mental practice. In T. S. Horn (Ed.), *Advances in sport psychology* (pp. 221-250). Champaign, IL: Human Kinetics.

Oña, A. (1998). *Control y aprendizaje motor*. España: Ed. Síntesis.

Palmi, J. (1991). *La imatgeria (IMAGERY) com a tecnica I programa d´intervenció psicologica en l´esport*. Bellaterra: Publicaciones UAB.

Richardson, A. (1969). *Mental imagery*. New York: Springer.

Roosink, M., & Zijdewind, I. (2010). Corticospinal excitability during observation and imagery of simple and complex hand tasks: Implications for motor rehabilitation. *Behavioral Brain Research, 213*(1), 35-41.

Ryan, E. D., & Simons, J. (1983). What is learned in mental practice of motor skills: A test of the cognitive-motor hypothesis. *Journal of Sport Psychology, 5*, 419-426.

Sheffield, F. (1961). Theoretical considerations in the learning of complex sequential tasks from demonstrations and practice. In A. A. Lumsdaine (Ed.), *Student response in programmed instruction* (pp. 13-32). Washington, D.C.: National Academy of Science.

SooHoo, S., Takemoto, K., & MaCulagh, P. (2004). A comparison of modelling and imagery on the performance of motor skill. *Journal of Motor Behavior, 27*(4), 349-367.

Toussaint, L., & Blandin, Y. (2010). On the role of imagery modalities on motor learning. *Journal of Sports Science, 28*(5), 497-504.

Trujillo, H., Doddis, Z., & Ibacache, N. (1999). *Validación de instrumentos destinados a medir el estado de los alumnos con respecto a objetivos educativos-físicos del NB1 y NB2*. Chile: Centro de Perfeccionamiento, Experimentación e Investigación Pedagógicas - Ministerio de Educación.

Vealey, R. S., & Greenleaf, C. A. (1998). Seeing is believing: Understanding and using imagery in sport. In J. M. Williams (Ed.), *Applied sport psychology: Personal growth to peak performance* (pp. 237-269). Mountain View, CA: Mayfield.

Vieilledent, S., Kosslyn, A., Berthoz, A., & Giraudo, M. (2003). Does mental simulation of following a path improve navigation performance without vision? *Cognitive Brain Research, 16*, 238-249.

Vogt, S. (1995). On relations between perceiving, imagining, and performing in the learning of cyclical movement sequences. *British Journal of Psychology, 86*, 191-216.

Yaguez, L., Nagel, D., & Hoffman, H. (1998). A mental route to learning: Improving trajectorial kinematics through imagery training. *Behavioural Brain Research, 90*, 95-106.

Yue, G., & Cole, K. (1992). Strength increases from the motor program: Comparison of training with maximal voluntary and imagined muscle contractions. *Journal of Neurophysiology, 67*, 114-123.