Integration of Motor Imagery and Physical Practice in Group Treatment Applied to Subjects With Parkinson's Disease

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Background and Purpose. The application of motor imagery practice in the treatment of Parkinson's disease (PD) is a novel treatment approach for improving motor function. The purpose of this study was to compare group treatment using a combination of physical and motor imagery practice with group treatment using only physical practice in subjects with PD. *Methods.* Of 23 patients with idiopathic PD, 12 received combined therapy, whereas 11 received physical therapy alone. Exercises for both groups were applied during 1-h sessions held twice a week for 12 weeks. Comparable motor tasks provided to both groups included callisthenic exercises, functional tasks, and relaxation exercises. However, the experimental group was treated with both imagery and real practice, whereas the control group received only physical exercises. Outcome measures included the time required to complete sequences of movements, the performance of balance tasks, impairment and functional scores on the Unified Parkinson's Disease Rating Scale (UPDRS), and specific cognitive abilities (Stroop and clock drawing tests). *Results.* Following the intervention, the combined treatment group exhibited significantly faster performance of movement sequences than the control group. In addition, the experimental subjects demonstrated higher gains in the mental and motor subsets of the UPDRS and in the cognitive tests. Both groups improved on the activities of daily living scale. *Conclusions.* The combination of motor imagery and real practice may be effective in the treatment of PD, especially for reducing bradykinesia. The implementation of this treatment regimen allows for the extension of practice time with negligible risk and low cost.

Key Words: *Parkinson's disease—Physical therapy—Motor imagery—Mental practice.*

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The positive effect of physical therapy on the motor and functional performance of patients suffering from Parkinson's disease (PD) has been demonstrated in several studies.[1-3] The targets of physical therapy intervention are the impairments and functional limitations emanating from the disease. Its essence lies in teaching the patients strategies that bypass the basal ganglia–supplementary motor area (SMA) circuit through the "recruitment" of neurons in other brain areas, such as the premotor cortex. This is achieved via the application of external cues and cognitive strategies for the triggering and initiation of motor acts. Movement practice by using these strategies leads to improvement in the performance of functional tasks.[4-6]

Mental practice by applying motor imagery (hereafter referred to as "motor imagery practice") is defined as using the imagery of a motor act in an attempt to learn and improve outcome without an overt sensory input–motor output relationship.[7] Motor imagery practice has been proposed as an alternative mode of exercise therapy that bears little cost and has no safety risks. Its positive effects on motor performance and skill, especially when combined with physical practice, have been established.[8-9] Even with sparsely scheduled sessions of real practice, imagery rehearsal may strengthen the activity in certain neuronal loops.[10] Motor imagery practice is especially recognized for its role in enhancing the relearning of once-mastered skills with no need to change physical location and with no physical danger.[11-12] Its contribution to reducing anxiety and enhancing attention is also well substantiated.[9]

In regard to neurological disorders, the majority of studies to date have dealt with stroke patients. Of relevance to the current study are those in which combined physical and motor imagery practice were applied. For example, Page et al,[13] Jackson et al,[14] and Malouin et al[15] all have pointed to the advantages of a combined treatment regimen, composed of physical and imagery exercises, as compared with a conventional treatment of physical exercises alone.

As for patients with PD, the imagery rehearsal of a motor act prior to its real performance has recently been recommended.[6] Nevertheless, the brain activity in individuals with PD who are engaged in motor imagery has been shown to differ from that of healthy controls[16] and to last longer.[17] It has also been found that patients with PD encounter more difficulties in transferring imagery to real movements than do healthy subjects.[18] However, the information supplied by these reports is limited insofar as in one study, the brain activity of subjects was tested in the "off" condition,[16] and in a second study, testing was performed after only 1 session of imagery practice of a new graphomotor task.[18]

Motivated by prevailing evidence on the positive effects of imagery practice on motor performance,[8,9,19] we designed the current pilot study with the purpose of determining whether PD subjects would benefit more from the application of motor imagery practice combined with physical practice than from physical practice alone. In contrast to previous research,[18] practice in the present study was applied for a relatively long time period and the practiced tasks were selected from familiar everyday activities.

METHODS

Subjects

The participants were 23 community-dwelling subjects with idiopathic PD, who were recruited from local neurological clinics. Inclusion criteria included community-dwelling individuals with PD between stages 1.5 and 3 according to Hoen and Yahr's classification,[20] and no dementia (Mini-Mental State Examination [MMSE] score of at least 26 points).[21] Individuals were excluded from the study if they had neuromuscular or skeletal comorbidities that affected their motor performance, severe PD (grade 4 on Hoen and Yahr's scale), or ailments that prevented them from making moderate physical efforts.

Prior to enrollment in the study, the accepted participants signed an informed consent form, complying with guidelines of the Ministry of Health. Following stratification by age, gender, and disease stage, they were randomly assigned to the control or the experimental group. Subjects were asked not to change their medication during the intervention period. A detailed description of the characteristics of the sample is provided in the beginning of the Results section.

Intervention

The intervention protocol was carried out by the 1st author, aided by a 4th-year physical therapy student, in the physical therapy department of a regional hospital. Participants belonging to the experimental group received a combination of imagery and physical practice, whereas the control group received only physical practice on the same motor tasks. For each group, 1-h practice sessions were held twice a week for a total period of 12 weeks.

The protocol applied to either group during physical practice included 3 parts: 1) callisthenic exercises aimed at enhancing the performance of movements of the trunk, flexibility, muscular strength, balance, and coordination (15–20 min); 2) practice of specific functions aimed at improving the performance of crucial motor tasks, such as transfer activities, gait activities, and upper extremity instrumental skills (15–20 min); and 3) relaxation exercises. Examples of exercises belonging to each of the 3 categories are provided in Table 1.

Throughout both real and motor imagery practice, major emphasis was placed on improving the smooth performance of movement sequences that compose a specific activity of daily living (ADL) function, such as rolling from a supine to a prone position and back, standing up and sitting down, and walking. In addition, activities triggering balance challenges, such as standing on a narrow base and responding to perturbations, were practiced. Fine motor skills, such as buttoning, tying shoe laces, and writing were also practiced.

To facilitate performance, the instructor applied a number of external cues, such as stripes on the floor and rhythmic auditory stimulation by music or metronome. Additional cognitive strategies were used, such as alerting subjects to their own performance and breaking down complex sequences into simple movements.[6]

In the experimental group, motor imagery practice was integrated with the physical exercises in 1 of 2 sequences: 1) the imagery practice preceded the performance of the same task in reality or 2) the motor imagery practice first succeeded the physical exercise, with subjects attempting to improve on their previous performance through imagery practice, and then the real task was re-executed.

Relaxation exercises were the final component of all practice sessions. Unlike the control group, the experimental group rehearsed the previously practiced tasks during the relaxation period.

Symbolic imagery, external imagery (in which subjects "viewed" themselves executing the tasks as if shown in a video film), and internal imagery (recapitulation of the sensory experience of task performance) were applied in accordance with Appel's model.[23] Daily life functions were mentally rehearsed within the private confines of each individual's environment. An example of the use of symbolic imagery in motor imagery practice was the suggestion to subjects to "watch" a parade by encouraging them to listen to the music; pay attention to the rate, length, and height of the steps; and observe

Table 1. Examples of Exercises Comprising the Protocol of Physical Practice

Callisthenic Exercises	Functional Activities	Relaxation Exercises
Sitting without a support: • With the arms crossed in front of the chest, turning the shoulders far to the left and far to the right. • Raising one buttock as high as possible. • Swinging the arms up in opposite directions. • Standing position. • Throwing and catching a ball while in a broad tandem stance. • Reaching in different directions, including retrieving objects from the floor.	Moving from a sitting to a standing position: • Moving to the edge of the chair, bending forward, putting feet under the chair, pushing up using the arms. Walking: • Training for walking, stopping, changing directions and speeds, using auditory cues (clapping hands and metronome). • Practice of walking sideways and backwards.	• Gentle diaphragmatic and upper chest breathing. • Jacobson's progressive exercises,[22] which are based on tensing and relaxing different muscle groups.

the alternating movements of the upper extremities. An example of the introduction of external imagery was the instruction to subjects to watch a video film of themselves walking and then asking them to improve (via imagery) gait impairments, such as short steps or diminished upper extremity movements. The application of internal imagery can be illustrated by the alerting of subjects to their kinesthetic sensations during gait, such as the magnitude of hip flexion or the force of pushing off the floor during each step. Internal imagery for walking on different terrains or slopes and in different environments (e.g., home, outside) were also provided by the trainer. The instructions for imagery practice throughout the sessions involved accurate descriptions of the motor tasks, so that imagery performance could serve to enhance real performance of the same tasks.[24]

The duration of engagement in motor imagery practice without taking a break never lasted for more than 5 min. This time period is thought to be optimal for enabling concentration and motor improvement.[25] "Home assignments" were given to both groups with the same instructions for exercises. However, the control subjects were asked to rehearse the tasks only physically, whereas the experimental subjects were asked to practice the tasks both physically and via imagery.

Assessment

Four faculties were assessed using well-established tests: 1) *The performance of a movement sequence* composing a functional task was assessed by tests that evaluate the main problem of subjects with PD, which is bradykinesia, and that offer adequate psychometric qualities for PD.[26-29] 2) *Balance functions*[30-33] were tested to assess the degree of postural control. The tests were chosen by relevancy to PD subjects, as shown by Smithson et al.[31] 3) *Neurological and functional deficits* were measured by the well-accepted UPDRS.[34] 4) *Cognitive ability* was measured by 2 highly established tests that address cognitive problems, such as attention, planning, and spatial perception.[35,36] The tests were administered 1 day before the intervention and at the end of the intervention period. A short description of the applied tests is provided in Table 2.

The evaluators were an expert physician in neurology, who was assisted by a 4th-year physical therapy student. Both evaluators were blind to subjects' group assignment. All assessments were performed when subjects were in an "on" state, at the same time of the day and in the same setting.

Statistical Analysis

To evaluate the differential effect of the intervention in the experimental and the control groups, the baseline pretreatment values and the change between the postintervention and the baseline values of each variable were compared. Mixed effect models for repeated measurements were applied to compare continuous variables, and the chi-square test was used for the comparison of categorical variables.

The continuous variables included the results of the following tests: "timed up and go," time required to get up from a supine position, time required to lie down from an upright stance, time and number of steps required to rotate in a complete circle, length of "functional reach," UPDRS scores, and Stroop test scores.

Table 2. Tests Applied to the Experimental and Control Subjects

	Test	Task	Criterion Measurement
Performance of a movement sequence	Timed up and go[27,28]	Standing up, walking a distance of 3 meters, returning to chair, and resuming sitting.	Performance time (seconds)
	Standing up and lying down[28,29]	Standing up from supine lying position and returning to lying position.[25]	Performance time, mean of 2 trials (seconds)
	Turning in place 360 deg[28]	Standing and completing 2 full leftward turns, then 2 full rightward turns.	Number of steps and time for task completion (seconds)
Balance tasks	Tandem stance[30]	Performed twice, once with each foot leading and the other trailing. For each test, if terminated before 10 s elapsed, then 2 additional trials were allowed.	Performance time (seconds)
	Functional reach[32]	While standing parallel and near a wall, with shoulder joint flexed at 90 deg, elbow extended, and upper extremity forward, subject reaches as far as possible without moving feet.	Reach distance (cm)
	Shoulder tug[33]	Subject stands, while examiner pulls subject's shoulders backward from behind.	Ordinal scale of 5 points (1 best - remained steady–5 worst - fell backward without taking a step)
Mental, motor, and ADL performance	Unified Parkinson's Disease Rating Scale (UPDRS)[34]	Parts 1, 2, 3, and 6 of the UPDRS, including assessment of mental, ADL, motor, and Schwab and England's Activities of Daily Living scales, respectively.	Scores for each task range between 0 and 4, i.e., from normal to highly impaired performance. The overall score is the sum of its parts.
Cognitive tasks	Clock drawing[35]	Drawing clock digits in a circle.	Ordinal scale of 7 points (0 best–7 worst).
	Stroop Test (parts A and B)[36]	Determining the color of sequentially presented words, while ignoring the meanings of the words, which indicate a different color.	Time of task completion (seconds) and number of errors

All tests were performed and scored according to their guidelines. Detailed descriptions of each test can be found in the cited references. ADL = activity of daily living; UPDRS = Unified Parkinson's Disease Rating Scale.

These variables were entered as the dependent variables, whereas the independent variables were group assignment and the interaction between group and time-point (pre- or postintervention). This interaction allowed us to examine whether the change between the pre- and postintervention scores differed across groups.

The categorical variables were the scores of the "tandem stance," "shoulder tug," and "clock drawing" tests, for which 3 categories of improvement were established: improvement, no change, and deterioration.

RESULTS

Participants

There were 2 dropouts due to cardiac problems during the course of the study, 1 from the experimental group and 1 from the control group. No significant differences between the 2 groups were found on admission in terms of sex and age distribution, years of formal education, MMSE score, stage of the disease according to Hoen and Yahr's classification, disease duration, or prescribed medication. Major characteristics of the participants are described in Table 3.

Measurement Outcomes

Regarding the performance of movement sequences among the experimental subjects, significant improvement was found in the performance time of the tests "timed up and go" ($t = 3.80$, $df = 40$, $P = 0.0005$), "getting up from a supine position" ($t = 3.53$, $df = 19$, $P = 0.0023$), "lying down from an upright stance" ($t = 1.98$, $df = 19$, $P = 0.06$), and "number of steps required to rotate in a circle" ($t = 3.31$, $df = 61$, $P = 0.0016$). No parallel changes were found in the control group.

Table 3. Major Characteristics of the Experimental and Control Subjects

		Experimental	Control
Sex	Women	4 (33%)	4 (36%)
	Men	8 (66%)	7 (64%)
Age		67.4 ± 9.7	67.4 ± 9.1
Education (years)		13.7 ± 5.8	15.7 ± 4.8
MMSE		29.4 ± 1.1	29.3 ± 0.9
Disease stage (Hoen & Yahr)		2.29 ± 0.4	2.31 ± 0.4
Disease duration (years)		7.4 ± 3.1	7.8 ± 4.5
Medications	L Dopa	12 (100%)	9 (82%)
	Dopamine Agonists	6 (50%)	7 (64%)
	Anticholinergic	2 (17%)	3 (27%)
	Amantadine	6 (50%)	5 (45%)
	MOA-B inhibitors	7 (58%)	8 (72%)
	COMT inhibitors	4 (33%)	1 (8%)
	Antidepressants	1 (8%)	3 (27%)

MMSE = Mini-Mental State Examination; L Dopa = levodopa; MOA-B = monamine oxidase B; COMT = catechol 0 methyl transferase.

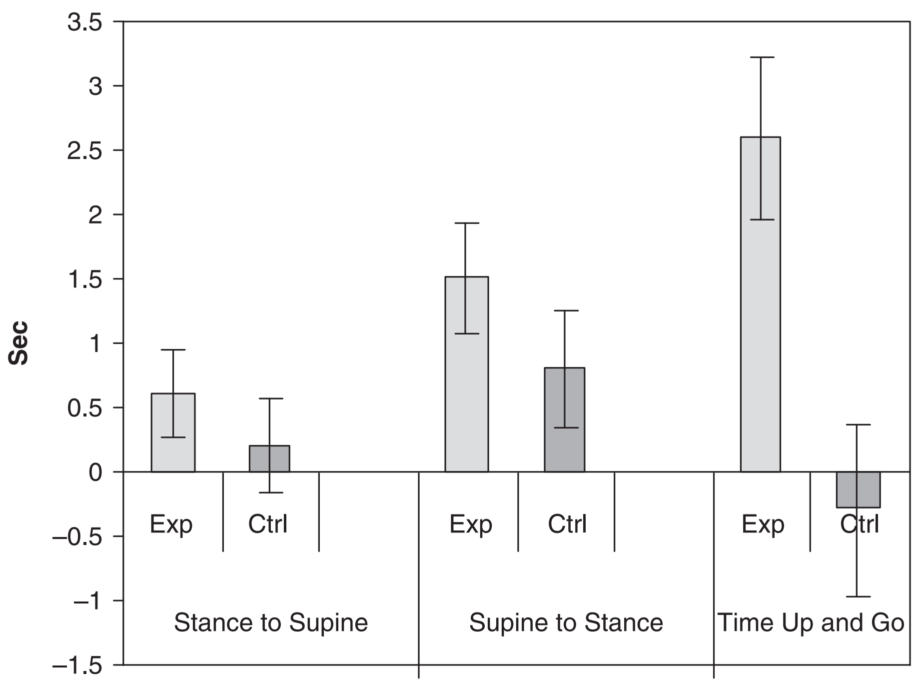

Figure 1. Mean decrease (and *SE*) in performance time (seconds) between pre- and postintervention in the 2 groups, in 3 sequential functional movements.

Balance function results were less unequivocal than the results for the performance of a movement sequence. The performance of functional reach improved in both groups, with improvement being marginally significant ($t = -1.92$, $df = 40$, $P = 0.06$; and $t = -1.82$, $df = 40$, $P = 0.08$ for the experimental and the control group, respectively), and with no difference found between the groups. A slight improvement in response to the shoulder tug test was noted only in the experimental subjects, among whom 40% displayed enhanced performance at the postintervention assessment, as compared with only 20% of the control subjects. However, these differences were not statistically significant. The Tandem stance test score was not affected by the intervention in either group.

The findings pertaining to neurological and functional deficits, as reflected by the UPDRS scores, are presented in Table 4. It can be seen that the experimental subjects improved substantially more than the controls, with the difference between the groups being especially remarkable for the mental section of the UPDRS test.

Table 4. Scores and Results of the Statistical Analysis for Subsets 1, 2, 3, and 6 of the Unified Parkinson's Disease Rating Scale

	Experimental Group		Control Group				
Section	Before Treatment	After Treatment	Before Treatment	After Treatment	Change: Experimental Group	Change: Control Group	Between-Groups Difference
Mental (1)	2.1	1.2	2.2	2.5	$P = 0.01$	NS	$P = 0.09$
ADL (2)	9.8	8.9	10.5	10.4	NS	NS	NS
Motor (3)	23.2	18.1	26.0	25.5	0.1	NS	NS
Schwab & England (6)	77.5	84.5	79.1	83.0	0.002	0.05	NS

ADL = activity of daily living.

Regarding the *cognitive* tests, the scores of both groups for clock drawing were within normal limits at the preintervention assessment (1.92 and 2.63 for the experimental and the control groups, respectively). At the postintervention assessment, the scores of the experimental group pointed to a slight improvement (decrease of 0.56 points), whereas the scores of the control group increased by 0.17 points. However, these changes were not large enough to represent significant changes between the groups.

Similarly, the scores on parts A and B of the Stroop test pointed to a nonsignificant improvement in the experimental subjects for part A and a marginally significant ($P = 0.1$) improvement for part B, with no parallel change among the controls. It is worthy of mention that a decrease in the number of performance errors was noted in 3 subjects in each group for part B of the Stroop test; yet the number of performance errors increased in 4 of the controls but only in 1 subject in the experimental group.

DISCUSSION

The purpose of this study was to determine whether a combination of physical and imagery practice is more effective than physical practice alone in alleviating the disabling symptoms of PD. For the majority of the variables, the findings point to a superior treatment effect of the former over the latter, thus confirming Morris's suggestion that rehearsal by motor imagery may be applied as a cognitive strategy for facilitating an upcoming motor act in subjects with PD.[6] In line with studies showing positive individual treatment effects of combined physical and imagery practice in subjects following a stroke,[13-15] the current findings indicate that combined therapy for patients with PD during the "on" condition may be more beneficial than physical practice alone. Perhaps the explanation for this phenomenon is that the combination therapy during the on condition facilitates the patients' engagement in cognitive tasks, such as motor imagery.

The positive effect of motor imagery practice on the performance of tasks that are composed of a sequence of movements indicates that imagery practice may reduce bradykinesia, one of the major debilitating effects of PD. This positive effect can be attributed to several factors: 1) The contents of the practiced imagery tasks included common everyday activities, such as getting up from a chair or from a supine lying position. The notion that imagery practice is especially beneficial to tasks that have been mastered by the subject in the past has been confirmed by previous studies.[37] 2) Members of the experimental group were advised to routinely rehearse movement tasks via imagery before performing them physically. Thus, in addition to the actual physical performance of everyday tasks, the same acts were practiced mentally. 3) For this group of tasks, the contents of the imagery practice were comparable to the contents of the tests. Conversely, the tasks in the other test groups were not practiced during training sessions. Perhaps the ability of PD subjects to improve a function increases with imagery practice of the same task. Yet they may have difficulties in transferring that learned task to the performance of a comparable task.

One exception to the tested movement sequences was the "timed turning in place" test, which was not affected by the intervention in either group. The number of steps taken to complete the turn decreased only in the experimental group. Presumably, imagery practice that focused on increasing the step length and reducing the number of steps contributed to the performance of the experimental subjects. Imagery practice may have helped them to better plan the number and length of the steps required to accomplish the task during the physical performance. The lack of improvement in performance time may perhaps be related to the difficulties encountered in dividing their attention,[38] thus being unable to simultaneously increase speed of performance and pay attention to decreasing the number of steps.

The treatment of balance dysfunction is another goal of physical therapy for PD. The choice of the balance parameters measured here was based on the study of Smithson et al,[31] who recommended tests to discriminate between patients and healthy individuals as well as to identify those subjects who are prone to falls. The unresponsiveness of the balance parameters to the intervention in either group could derive from several factors: 1) Balance responses are largely automatic, and it is difficult to cause substantial changes in these responses via training based on voluntary cognitive-driven efforts or via medication.[39] The failure to sufficiently improve the response to shoulder tugs, in which rapid effective responses are necessary, demonstrates this point. 2) Perhaps the time needed to practice the balance tasks was too short for producing significant outcomes. 3) Regarding the experimental paradigm, the imagery of the balance tasks used here may have been difficult to access, especially in a situation without movement, such as the tandem stance.

Three components of the UPDRS (mental, ADL, and motor), as well as the Schwab and England ADL Scale (which is appended to that assessment scale), were applied here. In the mental subscale of the UPDRS, the experimental subjects showed greater improvement than the controls. This finding is in agreement with those of Pavio[40] and Korn,[41] who showed that successful imagery practice of a task brings about an increase in motivation, reduces depression, and increases arousal.[36,37] As for motor improvement, the decrease of 5 points in the experimental group score is notable insofar as it indicates an improvement of 20% relative to the initial values (despite the marginal statistical significance).

The findings for the Schwab and England ADL Scale confirm the hypothesis that group practice enhances improvement in both groups, though the improvement was more enhanced in the experimental group. The significance of this finding needs to be explicitly addressed. Group practice of real tasks, which is devoid of the natural surroundings of each participant, lacks the advantage of imagery practice that can be tailored by each individual to his or her own living environment. This advantage of motor imagery practice could have been the underlying cause of the superior functional achievements made by the experimental subjects.

In regard to cognitive abilities, some investigators suggest that imagery practice contributes to the development of cognitive strategies beyond its direct positive effect on the current practiced task.[40] Presumably, practice using imagery brings about an improvement in the ability to attend to cognitive challenges, thereby enabling superior performance. Because motor imagery practice requires concentration and mental engagement in spatio-temporal parameters, the improvement in the clock drawing test, which was noted only in the experimental group, may be attributable to that form of practice. Regarding the Stroop test,[36] the improvement in both parts A and B of the test was higher in the experimental subjects than in the controls. The challenges in that test, especially in part B, require attention and concentration, which were probably improved in the experimental subjects.

Limitations of this pilot study include uncertainty about the optimal dose of each intervention, uncertainty about the sensitivity of some of the outcome measures such as the UPDRS for this specific intervention, and the small number of participants. Due to the small sample size, several outcome variables produced marginal and nonsignificant statistical findings, which were hard to interpret. One example is the equivocal results found for the balance tasks. Considering the importance of balance functions to subjects with PD, a more comprehensive study is needed to determine whether these functions can be improved via imagery practice. In addition, future studies should include follow-up information.

CONCLUSIONS

The integration of motor imagery practice with physical practice for patients with PD may lead to a reduction in bradykinesia. Considering the clinical as well as the statistical significance of the findings,[42] larger trials should examine the integration of motor imagery practice with conventional physical practice for PD patients. Imagery routines could constitute an important component of the cognitive strategies provided to these patients. Given that a total time period of 1 h of practice was applied to both groups and that the gains of the experimental subjects were comparable to or higher than those of the controls, reduction of physical practice time in favor of motor imagery practice may be considered. The trend of improvement in the cognitive variables may point to the contribution of motor imagery practice to attentional skills. The combination of motor imagery and physical exercises for at least 6 weeks (12 sessions) for PD patients appears to have positive effects on the performance of motor and functional tasks.

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