

ACTION OBSERVATION TREATMENT. UNA BREVE PANORAMICA SU UN NUOVO STRUMENTO PER LA RIABILITAZIONE ED EDUCAZIONE IN AMBITO CLINICO, NEUROPSICOLOGICO E SPORTIVO

ACTION OBSERVATION TREATMENT. A BRIEF OVERVIEW OF A NEW TOOL FOR REHABILITATION AND EDUCATION IN THE CLINICAL, NEUROPSYCHOLOGICAL AND SPORTS FIELDS

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Abstract

In recent years, research in the clinical, neuropsychological, educational and sports fields has contributed to the development of numerous and different therapeutic interventions, radically changing the ability to deal with problems of various kinds in these areas. The objective of this brief review illustrates the new rehabilitation and educational approach of AOT (ACTION OBSERVATION TREATMENT), which exploits the neurophysiological mechanism of mirror neurons. Its potential for motor recovery could be used in clinical, educational, neuropsychological and sports settings.

Negli ultimi anni, la ricerca in ambito clinico, neuropsicologico, educativo e sportivo, ha contribuito allo sviluppo di numerosi e diversi interventi terapeutici cambiando radicalmente la capacità di affrontare i problemi di diversa natura in questi ambiti. L'obiettivo di questa breve review illustra il nuovo approccio riabilitativo ed educativo dell' AOT (ACTION OBSERVATION TREATMENT), che sfrutta il meccanismo neurofisiologico dei neuroni specchio. Il suo potenziale per il recupero motorio potrebbe essere utilizzabile in ambito clinico, educativo, neuropsicologico e sportivo

Keywords

neurorehabilitation, mirror neuron system, action observation treatment, evidence-based medicine, learning, health, sport, autism.

Introduction

Research in recent years has stimulated the development of numerous and different therapeutic interventions that have radically changed our ability to deal with problems of different nature in clinical practice. (eg. Buccino, 2014). Thanks to studies coming from neuroscience, it has been widely demonstrated, using transcranial magnetic stimulation (TMS), EEG, MEG and brain imaging techniques (PET, fMRI), that the observation of actions performed by a subject can activate in the person who observes specific “brain networks” responsible for the same actions that the observed subject is carrying out. For example, when the subject observes people who are performing routine actions such as walking, tying their shoes, etc., the same neural structures involved are activated in that subject for the effective execution of the actions that the observed person is carrying out. The essence of the mirror neuron mechanism is the transformation of sensory information into a motor format (eg. Fabbri-Destro & Rizzolatti, 2008), which is also involved in motor learning (Halsband et al., 2006). The mirror neuron system is active in the imitation of new movements (Buccino et al., 2004). Starting from these studies, the AOT (ACTION OBSERVATION TREATMENT) stands out as a new rehabilitation approach that adopts the functioning of the areas equipped with the observation-action execution combination mechanism. The neurological mechanism of the mirror neuron system is used in motor disorders for its potential role in learning for motor recovery (Buccino, 2014). The clinical efficacy and neural mechanisms of action-observation therapy and mirror therapy in stroke patients were observed (Hsieh et al., 2020). Many studies (Borges et al., 2018; Kim et al., 2017) have shown that observing this particular action is an effective way both to learn and to improve the success of a performance, of one or more specific motor skills. (eg. Vogt, 2007). And it is in this context, therefore, that AOT is inserted, as a clinical tool that can be applied to various areas, such as that of enhancing health in general, sports and clinical rehabilitation. The objective of this study, in addition to providing a brief overview of the use and usefulness of this technique in the rehabilitation and clinical field, aims to outline different applications, less investigated, such as the sports field, social skills and support in educational programs for children with autism spectrum disorder. This can be useful to help future publications and research, to have an overview of the Action Observation Treatment and its uses. In order to do this, searches have been selected as follows: (i) Consultation of the following search engines: PubMed, Google Scholar, Researchgate (ii) Priority to the most recent research (2015-2020) (iii) Selection of research published in peer-reviewed journals for greater validity, reliability

and reliability of the information. (iv) Selections of articles with abstracts available in English or Italian (v) Selections of studies that referred to the clinical, neuro-rehabilitation and sports fields. In total, over 400 publications on the subject were found. For this brief overview, 35 articles were reviewed that fit the above criteria.

1. Background: Action Observation Treatment

The Action Observation Treatment (AOT) can be used in different areas and contexts, especially in the rehabilitation, using the observation of other's actions. During Action Observation Training (AOT) the patient is asked to carefully observe the actions presented through a video clip or performed by an operator, in order to try to reproduce them following the observation (Mulder, 2007). only type of action during each rehabilitation session (Buccino, 2014). The hypothesis that imitating observed gestures can lead to reorganization of the primary motor cortex, contributing to the formation of the motor memory of the observed action, has been confirmed (Buccino, 2014; Franceschini et al, 2010; Brunner et al., 2014 for insights), physiological process at the basis of motor learning (Celnik et al., 2006). AOT allows the activation of specific areas of the cerebral cortex (Buccino, 2014; Franceschini et al., 2010; Brunner et al., 2014) by reinforcing intact cortical networks and facilitating the activation of damaged areas, preventing changes in the cortical reorganization occurring after inactivity and disuse (Wang et al., 2010). The efficacy of AOT has been shown in multiple studies (Mattar & Gribble, 2005; Celnik et al., 2006; Stefan et al., 2005; Buccino, 2014; Franceschini et al., 2010; Brunner et al., 2014). It has been proven (Mattar & Gribble, 2005; Caligiore et al., 2017) that the mechanisms that link observation to action and vice versa facilitate motor learning. Neural representations of new skills can be acquired visually on the basis of observation and this process does not depend on the use of conscious strategies, but is based on the implicit functioning of motor systems. The study conducted by Mattar & Gribble (2005) showed that subjects who observe the video of a person learning a new movement through a robotic arm, achieve better results when compared with other subjects who do not observe such video. This type of learning, observational and not by direct experience, has already been outlined and described in the past by various authors, in particular by Bandura (Bandura, 1977) who introduced the concept of modeling and learning by observation or vicarious learning. According to the author, such learning includes four main components: Attention (observers must pay attention to what is happening around them), Motivation (the more motivated the person, the more they tend to direct their attention and energy to learn) , Memory (the observer not only recognizes the observed behavior, but also must remember it later), Initiation (the observer must be physically and / or intellectually capable of producing the act in whole or in part) (Bandura, 1977). Some results show that a specific motor memory is created thanks to observation, similar to that induced by practicing movements (Stefan et al., 2005). It has also been shown that observing the behavior of others not only facilitates motor learning but also allows the formation of a motor memory trace both in healthy people and in people with various diseases, such as stroke (Stefan et al., 2005). In this regard, some authors have highlighted that thanks to AOT, greater motor strength is also achieved in performing simple movements (such as moving a finger), compared to people who do not use this technique (Porro et al., 2007). Furthermore, AOT improves the motor image used as a strategy for learning a complex motor movement (Gatti et al., 2013). AOT, therefore, is a new rehabilitation approach that exploits the mirror mechanism, and its potential role in motor learning, for motor recovery itself.

2. Action Observation Treatment in various clinical and rehabilitative areas

AOT is a treatment used in various clinical and rehabilitation areas. Has had satisfactory results in the treatment of posture, *“Given the ease with which action observation training can be applied in the home, it offers a promising, safe and economical approach as an ad-*

junctive therapy to routine balance training.” (p.1 Patel, 2017) and during rehabilitation after orthopedic interventions *“In addition to conventional physiotherapy, AOT is effective in the rehabilitation of postsurgical orthopedic patients.”* (p.1, Bellelli et al., 2010). In particular, it was found to be effective in rehabilitating patients after total knee replacement (Villafañe et al., 2017): *“adding action observation training to conventional inpatient physiotherapy is associated with a greater degree of recovery in patients who have undergone a primary total knee replacement.”* (p.1, Villafañe et al., 2017). The study shows that with the self-administration of an AOT treatment together with conventional hospital physiotherapy, patients had a greater recovery of functionality. The AOT technique / treatment has also had positive effects in patients with chronic aphasia in the recovery of verbs: *“Action observation therapy may become a useful intervention strategy to promote verb retrieval in aphasic patients.”* (p.1, Bonifazi et al., 2013). These new findings may represent an effective alternative approach to traditional rehabilitation programs for lexical deficits. Regarding the strengthening and rehabilitation of children with motor coordination disorders (DCD): *“In typically developing children, imitation was significantly enhanced for AO + MI (Motor Imagery, for details see Ridderinkhof & Brass, 2015) compared to observe then imitate. Combined AO + MI instructions therefore represent a promising new approach to refining performance of everyday rhythmical actions in children both with and without DCD, with implications for movement therapy and sports training.”* (p.1, Scott et al., 2020). The study found that the combined AO (Action Observation) + MI (Motor Imagery) instructions resulted in an improvement in imitation ability in children with and without DCD compared to their natural imitation strategies. This study provides additional support for the use of AO + MI, a low-cost and easy-to-administer training tool for improving fine motor skills in children. The AOT was also used in the reduction of bradykinesia of finger movements *“(…)These findings suggest that the dopaminergic state contributes to the effects of action observation, and this training may be a promising approach in the rehabilitation of bradykinesia (…).”* (p.1, Pelosin et al., 2013). Regarding the treatment of some types of multiple sclerosis: *“AOT promotes clinical improvements in MS patients through structural and functional modifications of the action observation matching system.”* (p.1, Rocca et al., 2019). In fact, the study found that a 10-day AOT on motor performance of the dominant hand in patients with MS, with motor impairment of the upper limbs, promotes clinical improvements, through structural and functional modifications of the matching system of observation of action. The study by Sakzewski et al. (2014) shows that *“There is modest evidence that intensive activity-based, goal-directed interventions (eg, constraint-induced movement therapy, bimanual training) are more effective than standard care in improving UL and individualized outcomes.”* (p.1, Sakzewski et al., 2014). This study aims to review the effectiveness of non-surgical upper limb therapies for children with unilateral cerebral palsy, who therefore have reduced upper limb function, affecting independence, participation and quality of life, thus requiring an effective rehabilitation. According to a pilot study conducted by Molinaro et al., (2020), this type of therapy (AOT) is also effective at a distance (for example via videoconferencing platforms such as Skype, Google Meet etc): *“Action Observation Treatment is therefore a promising approach that can be used on a large scale in a telerehabilitation setting.”* (p.1, Molinaro et al., 2020). The motor system of the elderly also seems to benefit from AOT: *“Intervention for action observation using unskilled model combined with motor imagery was effective for improving motor performance during the early phase of motor learning.”* (p.1, Kawasaki et al., 2018). The authors noted that the AOT intervention is effective for improving motor performance during the early stage of motor learning. Action Observation Therapy is also used as a tool for neurological diseases. Some authors have outlined which areas are mainly involved in the mechanism underlying the “mirror” reproduction of the AOT technique. These areas are: the frontal lobe (mainly in the inferior frontal gyrus) and the posterior parietal lobe (mainly in the inferior parietal lobule). This circuit (MNS) has been referred to by several studies as *“mirror neuron system”* (Plata Bello et al., 2017). This study analyzes the “problem” that previous studies for the most part, have been carried out with transitive actions using the upper limbs, that is, the type of actions that consist

of interactions with objects, such as eg lift a pencil and / or use it. These actions, as demonstrated by numerous researches (Buccino et al., 2014; Peng et al., 2019), significantly increased the activity of the MNS area. This has shown the effective usefulness of this technique. The author of the study, however, proposes to expand the studies to evaluate the effectiveness of AOT, even on non-transitive actions, i.e. those in which there is no interaction with an object (for example, mimicking the opposition of the index finger and the thumb like the pantomime of a precision grip). Even if intransitive actions, compared to transitive ones, produce a lower activation of the MNS circuit, according to the author and according to several studies (Plata-Bello et al., 2014) AOT can also be effective for improving and enhancing these types. of gestures and actions, expanding the effectiveness of the therapy itself. Furthermore, the study underlines the effectiveness of AOT therapy, both by referring to transitive and intransitive actions / techniques, in different neuropsychological pictures, such as stroke, aphasia, Parkinson's disease and cerebral palsy (Celnik et al., 2008; Sugg et al., 2018; Kim et al., 2015; Pelosin et al., 2015, Caligiore et al., 2017). The study concludes: “Action *observation therapy (AOT)* is a developing neurorehabilitative tool, which is based on the existence of the mirror neuron system (MNS, Iacoboni & Dapretto, 2006). AOT proposes that motor symptoms of different neurological disorders can improve with the observation and imitation of different actions.” (p.1; Plata-Bello, 2017). The Action Observation is used in the treatment of people affected by Stroke (Borges et al., 2018), even with hemiplegia (Tani et al., 2017). An interesting study conducted by Serotti et al. (2015) demonstrated encouraging preliminary results on the efficacy of AOT treatment on children with cerebral palsy.

3. Action observation treatment for Sport and skill building

Neuroscience has helped to develop a line of research on the correlation between mirror neurons and sports performance (eg. Eaves et coll. 2016; Kim et al., 2017). We know that sensory-motor neurons are activated both when an individual performs an action and when he observes it while it is performed by others (Buccino, 2014; Franceschini et al., 2010; Brunner et al., 2014). The neurons of the observer “mirror” (Rizzolatti & Craighero, 2004) literally what happens in the mind of the observer, as if it were the observer himself carrying out the action. This phenomenon not only helps to explain some dynamics underlying social behavior and therefore also of competitive behavior, but it can be used to enhance the athlete's preparation techniques in all sports disciplines (Buccino, 2014). To explain exactly how mirror neurons can contribute to the improvement of athletes' performance, it is necessary to start from the fact that they are the basis of experiential learning (eg. Eaves et coll. 2016; Kim et al., 2017). They can become a fundamental aid for coaching during technical training of the young athlete. In fact, if the observation of the behavior of a subject involves for the observer the activation of the same neurons as the observed, we can deduce that in the learning process by imitation the neurons of the young athlete who observes will faithfully reflect what is happening in the mind. of the “expert athlete”, facilitating the learning of the motor gesture (Kim et al., 2017). Therefore, imagination can improve sports performance, even if its effectiveness is mediated by the ease with which athletes can generate images. (Motor Imagery is a rehabilitation technique and approach based on the imagination of a certain action. It is based on the assumption that even just by imagining the action, the same brain circuits are activated as when the action itself is actually carried out, for details see Ridderinkhof & Brass, 2015) . Establishing techniques that improve this imaging ability is desirable to improve the effectiveness of imaging interventions. In a research, D. J. Wright et all. (2014), subjected three groups of golfers to different training for 8 weeks. The first group underwent imaging training. The second group to an action observation training. The third group to a physical training training. This experiment represented the first attempt to compare changes in image generation as a result of imaging training or action observation. The results indicated that both trainings over a 6-week period produced similar significant improvements in the ease of the participants to generate visual images. These improvements remained

constant after a 2-week period. This indicates that both techniques appear to be equally effective in improving the generation of visual images in sportsmen (golfers). Imagination is a process that uses multiple senses to create a representation of an action in the mind typically in the absence of obvious physical movement (Jeannerod, 1994; Vealey & Greenleaf, 2010). Since the imaginary involves the creation of a symbolic representation from memory, it can be seen primarily as a top-down process, (Holmes & Calmels, 2008). A growing body of research implies that imaging can be an effective technique for improving aspects of motor performance, particularly when used with motor tasks involving cognitive elements (Driskell, Cooper, & Moran, 1994; Feltz & Landers, 1983). As such, the images are used regularly by athletes with the aim of improving their performance. Some authors (eg. Eaves et al. 2016) point out how motor imaging (MI, Motor Imagery Training, see Driskell et al., 1994 for details) and action observation (AO) have traditionally been viewed as separate techniques, which can be used in conjunction with physical practice to improve motor learning and rehabilitation. The two processes are able to guarantee a similar activity in the motor system. Based on these findings, the authors initiated research to investigate the effects of combined use. The results provided compelling evidence that simultaneous AO + MI causes increased activity in motor regions of the brain, compared to independent MI or AO. Additionally, there is a number of evidence indicating that combined AO + MI may also have a more direct impact on motor outcomes. Thus, the combined AO + MI, along with physical practice, has been recommended as a potentially more effective tool for motor learning and rehabilitation professionals. *“Action observation training and motor imagery training have independently been studied and considered as an effective training strategy for improving motor skill learning (...)”* (p.1 Kim et al., 2017).

The advantages of using observation in sport, therefore, are many. For example, by integrating observation technique to support more traditional physical training sessions, it could be useful for improving and optimizing the training itself (Holmes, P., & Calmels, C. (2008)). By integrating the Action Observation (A.O.) into routine training, you could decrease the load and fatigue of physical training and reduce potential injuries and injuries (Holmes, P., & Calmels, C. (2008)). Furthermore, in the light of the research carried out by Calvo-Merino et al. (2005) and Calvo-Merino et al. (2006), it is recommended to use models for observation, which have skills similar to those of observer, this to promote more optimal motor representations. An observer should have visual familiarity and motor familiarity with the observed action (Holmes, P., & Calmels, C. (2008)). Also, observing how a team or more players move, (such as their attacking and defending techniques or the exchange of actions between two opponents), could allow athletes to anticipate the actions of others more effectively. Understanding the actions of others, in terms of movement kinematics, allows the observer to be able to make predictions on the opponent's movements and to anticipate their objectives (Holmes, P., & Calmels, C. (2008)). Finally, in sports rehabilitation, athletes can recover more quickly after viewing different sports videos and repeating movement sequences. Observation of relevant sports sequences could allow for cortical structural changes, reorganization and reinforcement in motor architecture. Used in conjunction with traditional therapies, observation can trigger greater involvement of the neural structures that support rehabilitation (Holmes, P., & Calmels, C. (2008)).

4. Action Observation, Social Skill and Autism Spectrum Disorder

Social interaction is fundamental for the human being. Some authors argue that man was born with an innate ability and desire to interact socially (Meltzoff & Moore, 1997). This need has been suggested as a pivotal factor in the evolution of human skills, including art, language, theory of mind and empathy (Ramachandran, 2000). One system proposed to underlie many aspects of social cognition is the mirror neuron system (Gallese et al., 2004). As previously mentioned, these neurons have been called “mirrors”, precisely because of this ability to “mirror” in one's mind, what happens in the observed subject, as if it were the observer himself who performed the action. Effectively, the observation of action moves the functional reorgan-

ization of the brain and simplifies motor learning through the mirror neuron system (Rizzolatti & Craighero, 2004). Therefore, the observation of the actions and behavior of another person alters the neural activity of the observer (Meltzoff & Decety, 2003). This mirroring facilitates the understanding of the purpose of the action performed by others, without requiring higher cognitive processes such as reasoning (by Pellegrino et al., 1992). It is hypothesized that in humans, mirror neurons, compared to other animal species (for example monkeys), have evolved further to represent not only movement but also the intentions, thoughts and feelings that motivated a certain action. possibly through reciprocal connections with other connections of the brain, such as the limbic system or the medial prefrontal cortex (Meltzoff & Decety, 2003). It has been suggested that this evolutionary step provided the basis for perhaps unique human social skills, such as the theory of mind, empathy and language (Gallese, 2001). In this context, it is interesting to consider the autism spectrum disorder (ASD). People with autism spectrum disorders (ASD) are generally identified with deficits in social interaction and interest in the surrounding context, in language development and in the presence of repetitive behaviors (DSM-5, American Psychiatric Association, 2013). Literature suggests that social deficits are attributable to a dysfunction in the mirror neuron system (Fecteau et al. 2006; Iacoboni & Dapretto 2006; Oberman & Ramachandran 2007; Rizzolatti et al. 2009), although, in subjects with ASD, the model of activation of this system during observation and imitation has not yet been clarified and whether this system is somehow interrupted (Hamilton, 2013). Many studies do not reveal significant differences in the functioning of the mirror neuron system between subjects with ASD and subjects with typical development during visual-motor imitation and gesture observation tasks (Poulin-Lord et al., 2014; Marsh & Hamilton, 2011). In general, there is instead evidence that children with ASD fail to imitate meaningless actions or gestures (Rogers et al., 1996; Bryson et al., 1998) while having a normal result with other imitation tasks, such as common gestures, especially if directed to a goal (Rogers et al., 1996; Meltzoff, 1999; Aldridge et al., 2000). An aspect that, in the analysis and treatment of subjects with ASD, is taken into consideration in a limited way and only as an “accessory symptom” is the motor aspect (Ming et al., 2007). In fact, several studies show that individuals with ASD often have problems of delay in the development of gross motor skills, abnormal gait, postural instability and coordination problems (Ming et al., 2007; Bhat et al., 2011; Mieres et al., 2012; Kaur et al., 2018; Holloway & Long, 2019). Holloway & Long (2019) affirm that there is a close relationship between motor skills and the component of social interaction in subjects with ASD. In fact, research reports that children with ASD play a narrow range of activities when compared to their peers, and often in a solitary way (Potvin et al., 2013) and prefer sedentary activities, such as TV, video games (Simpson et al., 2018). Some researchers, considering the motor aspect and social difficulties, have hypothesized that the limited extension of motor skills used may lead to a lower chance of developing social relationships which then leads to a decrease in participation in social activities (Holloway & Long, 2019). Indeed, many studies have shown a positive impact on the social skills of children with ASD who participated in intervention programs based on movement development (Srinivasan et al., 2018). Furthermore, physical activity programs containing jogging, swimming or yoga have been found to be effective in improving stereotypical behaviors (Bremer et al, 2016; Srinivasan et al., 2014) and in emotional and social functions (Bremer et al, 2016). Morrier & Ziegler (2018) found an increase in social interaction skills in children with ASD who had undergone a rehabilitation intervention in which they were accompanied by typically developing children during recreational activities. Interventions that use role play and imitative games have also had a positive impact on the social functions and attention of children with ASD. All of the above considered, we believe that an AOT intervention in the educational field on subjects with autism spectrum disorders could be a valid support, complementing the techniques already in use, to improve the empathic and social skills of children with ASD. Considering the studies by Holloway and Long (2019), according to which the limited extension of motor skills can be one of the factors that affects the development of social relationships and activities, integrating current psychoeducational practices with an AOT intervention could help

the development of motor skills and, consequently, provide greater support for the development of social relationships. An important role is played by the choice of the type of actions and behaviors to be placed as a point of observation, opting for activities that fall within the social sphere and of contact with “the other” and that have a specific purpose.

Conclusions and future perspectives

Although several studies have been published (Mattar & Gribble, 2005; Celnik et al., 2006; Stefan et al., 2005; Buccino, 2014; Franceschini et al, 2010; Brunner et al., 2014) reporting the efficacy of AOT therapy in patients with neurological diseases, stroke, cerebral palsy and as a rehabilitation tool in sports, new research is needed to consider this technique a standard therapy. For example, it would be interesting to study, in the future, whether AOT can also lead to improvement in patients with multiple sclerosis or traumatic brain injuries; however, insufficient randomized studies have been conducted with this type of patients to date. Future research could also investigate the results of neurofunctional studies, such as neuroimaging studies, to provide new information on the functioning of the mirror neuron circuit in various pathological conditions and on the plastic changes of the brain following the use of AOT (Ferrari & Rizzolatti, 2015). Furthermore, the AO technique appears to be potentially effective also in the area of enhancing social skills (Meltzoff & Decety, 2003) and in autism spectrum disorders (es. Srinivasan et al., 2018). In fact, especially in the latter, they seem to benefit from observing the movements of others and inserting this type of program in the school curriculum could lead to important benefits. Last but not least, future studies could demonstrate how the effectiveness of this technique is related to a better quality of life for the patient. Indeed, reducing the social and functional limitations of patients with neurological disorders would inevitably lead to an improvement in their quality of life and the reduction of complications related to the disease. All this would help convert AOT into a standard therapy for use in hospitals, rehabilitation centers and sports centers. In recent literature, theoretical and empirical approaches have been used in the analysis of AOT as a new rehabilitation method which, by exploiting the mechanism of mirror neurons and their role in learning, can be used in the clinical, rehabilitation and sports fields (Nedelko et al., 2012). In this work, a brief overview of the existing literature was presented, which highlighted the state of the art regarding the efficacy of AOT therapy in various neuropsychological situations, such as stroke, aphasia, Parkinson’s disease and cerebral palsy. Furthermore, as previously discussed, AOT plays a decisive role in sports rehabilitation (Wright et al., 2014). This work presents possible future developments that mainly concern the expansion of the technique to other neuropathological conditions (such as multiple sclerosis or traumatic brain injuries), the monitoring of possible plastic changes of the brain and the consequent improvement of the quality of life of the patients. Further studies on AOT could, therefore, definitively endorse the effectiveness of the technique and significantly improve the functional and social limits produced by neurological disorders of various kinds. The decrease in these limitations is clearly associated with an improvement in the quality of life and in the survival periods of patients, thanks to the reduction of complication rates (associated with the aforementioned limitations). Therefore, new and appropriate research is needed to convert AOT into standard therapy in our hospitals, rehabilitation and sports centers.

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