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The impact of Kinesio Taping® on manual dexterity in Multiple Sclerosis: A double-blind, parallel-arm, pilot study

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ABSTRACT

Introduction: A range of signs and symptoms that often impair up-per extremity function characterizes Multiple Sclerosis (MS). People with MS may have impairments that make some activities of daily living difficult and reduce functional independence. A multidisciplinary rehabilitation approach, combined with pharmacological treatment, can be helpful in improving hand and upper limb function in people with Multiple Sclerosis. The purpose of this study is to evaluate the effects of Kinesio Taping® in addition to upper limb-specific rehabilitation on dominant hand in people with Multiple Sclerosis.

Methods: In this pilot study, patients were divided into two groups according to clinical indications: the experimental group underwent application of Kinesio Taping®, while the control group of Inelastic-Tape, 3 times a week for 4 consecutive weeks. All patients were assessed at baseline (T0) and after 4 weeks (T1) with scales for manual dexterity, fine motor skills, strength and quality of life. Results: Statistical analysis showed that the hand-dominant function of the entire sample improved. Patients in experimental group achieved greater benefits in manual dexterity and the ability to perform activities of daily living.

Conclusion: It would appear that Kinesio Tape® in addition to appropriate and individualized physical therapy is effective in improving some aspects of hand function.

1. Introduction

Multiple Sclerosis (MS) is a neurodegenerative, chronic, demyelinating disease that affects the central nervous system. The Atlas of Multiple Sclerosis is a registry compiled by the Multiple Sclerosis International Federation (MSIF), which reports that the estimated number of people with Multiple Sclerosis (pwMS) worldwide has increased to 2.8 million in 2020 (30% higher than in 2013); and the global prevalence in 2020 is 35.9 per 100,000 people (Walton et al., 2020).

The incidence and prevalence of MS in Italy has increased over the last fifty years. Although genetic background may explain the basic predisposition to develop MS, epidemiological data indicate that environmental factors play an important role in determining the risk of developing the disease in the Caucasian population of the Country (Puthenparampil et al., 2022). Specifically, in Italy, the Italian association for Multiple Sclerosis (AISM) has estimated that by 2022 there will be 133,000 pwMS – 3600 new cases each year – with a prevalence of 215 cases per 100,000 people. This high incidence causes a social cost of 6, 000,000,000 euros per year (Associazione Italiana Sclerosi Multipla et al., 2022). MS causes a progressive reduction in physical and cognitive functions of pwMS, to the point that continuous care is required. Considering that the effect on lifespan is limited, this entails a high economic burden on society, especially in Italy, where the role of caregivers is central in the management of the disease (Battaglia et al., 2022).

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MS is a common, chronic, serious and progressive disease that, at least for the time being, cannot be cured. However, we now have effective treatments (both pharmacological and rehabilitative) that can decrease the frequency and severity and slowing down the progression of disease. The choice of treatment involves a targeted approach to ensure personalization, considering the individual patient's disease characteristics, needs and lifestyle habits (Rudick et al., 1997). It is critical to start effective treatment early, to reduce disease activity and significantly prevent the accumulation of disability and neurological damage with long term benefits (Landfeldt et al., 2018).

MS is characterized by a variety of signs and symptoms that manifest on different functional systems. PwMS reported fatigue, difficulty walking, vision problems, muscle weakness, spasticity, as well as cognitive and emotional impairments (McDonald and Compston, 2006).

Balance control is a complex function of our body, requiring the processing and integration of sensory and motor information from different systems, such as the cerebellum, spinal cord, brain and visual areas. MS can impact this function, making even what for many are common actions of daily living complicated, limiting autonomy and thus worsening quality of life. It has been documented that the greatest disability is related to walking (Kurtzke, 1983). For this reason, several tools have been studied to estimate balance control (Giovannini et al., 2022). The most frequent manifestation of condition involves balance, and ambulation is often the first manifestation with an increased risk of falls (Castelli et al., 2019). Drugs and rehabilitation are the most spread approach to improve functional control and quality of life of these patients (Castelli et al., 2022; Latino et al., 2017; Prosperini et al., 2020).

Moreover, upper limb function is also often impaired by MS (Johansson et al., 2007). Considering evidence-based data, approximately 66% of pwMS have upper limb impairment (Johansson et al., 2007; Kister et al., 2013). In 75% of cases, these patients have impaired strength and dexterity, resulting in difficulty performing gross movements and manipulating objects (Bertoni et al., 2015). Given the bimanual nature of some activities of daily living, in fact, a manual dexterity deficit can make some activities, such as changing clothes, going to the bathroom, or washing hands (Yozbatiran et al., 2006). It has been reported that manual dexterity impairment causes a reduction in functional independence, quality of life and social participation in about 3/4 of pwMS (Yalachkov et al., 2019).

A multidisciplinary rehabilitation approach, combined with pharmacological treatment, can be useful in improving hand and upper limb function in pwMS(Lamers et al., 2016). However, despite the growing attention of the scientific community, to date there is insufficient evidence on the rehabilitation of manual dexterity of pwMS (Grange et al., 2022). Upper limb impairments, for pwMS, greatly affect autonomy and quality of life, but are often underestimated as clinicians focus more on lower limbs status, balance and walking. Therefore, it is critical to carefully consider the possible assessment and appropriate treatment of this topic.

Considering the role of upper limb dysfunction on the performance of daily life and the positive outcomes of lower limbs rehabilitation, a growing interest in research protocols on upper limb rehabilitation in MS can be detected in recent years. In addition to the effects of conventional upper limb rehabilitation programs (Sá, 2014), new rehabilitation strategies have emerged in the last decade: task-oriented training, sensory training, robotics and technology supported rehabilitation devices. Different types of upper limb rehabilitation strategies can improve upper limb function in MS (Lamers et al., 2016).

Moreover, considering pharmacological treatment, results of a randomized double-blind trial suggested that Modafinil 200 mg per day may improve upper limb function (Lange et al., 2009). A study considers the treatment of painful tonic spasms that can affect upper limb (Solaro and Messmer Uccelli, 2010). Results of a recent pilot study may suggest that, in pwMS with moderate-to-severe spasticity, a one-month treatment with nabiximols may improve spasticity symptoms and overall upper limb motor function (Pau et al., 2023).

A complementary rehabilitation approach to functional hand treatment is Kinesio Taping® (KT). It is a technique using a tape with specific properties (specific thickness and high elasticity), developed by Dr. Kenzo Kase starting in 1979 (Kaze, 1997). KT is used to treat various neuromuscular and musculoskeletal deficits, especially in combination with trunk control exercises (Cho et al., 2020; Lee et al., 2016). The use of the elastic tape could produce physiological effects such as reducing pain (by stimulating neurological structures), restoring muscle function, reducing spasticity and removing congestions (Kase et al., 2003).

In addition, some authors have highlighted the positive effects of KT for pwMS in trunk control, lower limb strength and motor performance (Cortesi et al., 2011; Costantino et al., 2016) and the effect on balance of KT in pwMS (Cortesi et al., 2011; Sebastião et al., 2024; Yaşa et al., 2022).

Considering the literature review, there is no evidence on the role of KT on upper limb in pwMS. The purpose of this study is to evaluate the effects of this non-invasive tool, KT, on dominant hand function in pwMS.

2. Materials and methods

2.1. Study design

This was a pilot, blinded, parallel-arm study. PwMS regularly attending the Multiple Sclerosis Center were included in the study if they met the following inclusion criteria: (i) diagnosis of MS defined according to McDonald's criteria (Thompson et al., 2018); (ii) clinical and radiological stability of the disease for at least one year; (iii) age $\geq$18 years; (iv) dominant hand deficit at 9 Hole Peg Test (9HPT) (greater than two standard deviations) (Grice et al., 2003); (v) Beck Depression Inventory-II (BDI-II) score $<$11 (Solaro et al., 2016).

In addition, the exclusion criteria were as follow: (i) skin injury or skin pathology at the treatment site, (ii) presence of dominant hand spasticity (Modified Ashworth Scale, MAS) $\geq$ 3 (Bohannon and Smith, 1987); (iii) allergy to the Kinesio Tape® or to the inelastic adhesive bandage; (iv) inability to read, understand, and sign the informed consent.

Eligible pwMS were divided into two groups based on consecutive sampling: patients in the Kinesio Taping® group (experimental, KT-G) underwent application on KT in addition to conventional upper limb-specific rehabilitation treatment, while patients in the Inelastic Tape Group (control group, IT-G) underwent inelastic tape application in addition to conventional upper limb-specific rehabilitation treatment. All pwMS underwent application of KT (for KT-G) or inelastic tape (IT-G) 3 times a week for four consecutive weeks (12 applications in total).

2.2. Procedure

KT application was performed in KT-G following the course of the common extensor finger muscle, according to the method described by David Blow (2012). The upper limb was positioned with the elbow slightly flexed on a rigid plane, with the forearm, also resting on a rigid plane, in an intermediate prone-supination position. As far as the clinical conditions allowed, the hand was opened and rested with the palm on the rigid plane, keeping the wrist and forearm in axis. Measurement of the necessary tape was made starting from the lateral epicondyle to the tip of the III finger. Four tails were separated at one end of the tape, starting from the tip of the III finger to the wrist. Each tail was trimmed according to the length of the application finger to end at the base of the nail, rounding the ends to reduce the risk of accidental detachment. Afterwards, the patient was asked to rest the elbow on the tabletop, extend and abduct the thumb and flex the remaining four fingers on the palm without flexing the palm itself (Fig. 1a). The tape was applied starting from the tail corresponding to the II finger, adhering the tape to the skin while maintaining zero tension. The procedure was repeated for the other fingers. Once the ends of the tails were anchored, pwMS was

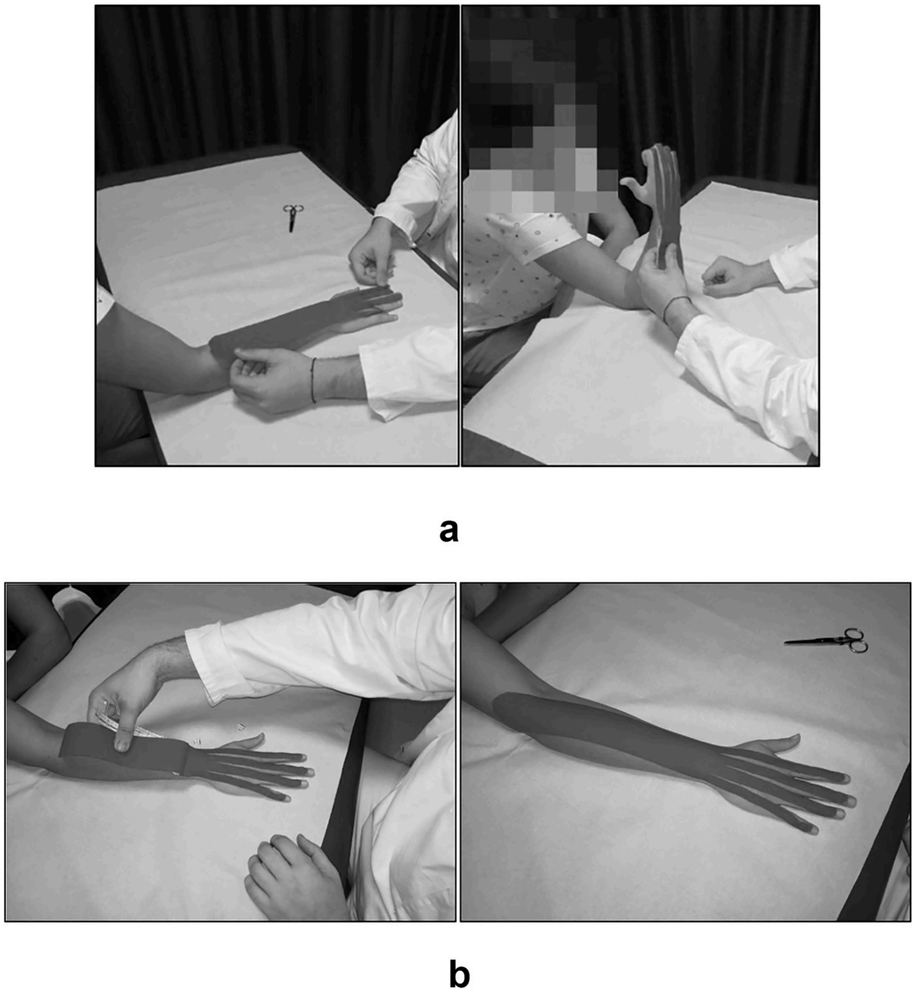

Fig. 1a and b. Fig. 1a and b show the stages of the KT application.

asked to close the fingers into a fist and flex the wrist to facilitate adherence of the tape to the back of the hand up to about 2 cm of the central body of the tape, always keeping the tension of the tape at zero (Fig. 1a). Finally, the tape was applied without tension in the direction of the posterior aspect of the lateral epicondyle of the humerus. At the end of application, gentle pressure of the tape on the skin was applied to promote activation of the heat-sensitive glue (Fig. 1b).

In the same way, the application of the Inelastic Tape was performed in IT-G.

2.3. Assessment

All pwMS included in the study underwent clinical assessment at the beginning of the research (baseline, T0) and at the end of the 4 weeks (T1). The evaluation included the use of some scales: questionnaires and performance tests. The questionnaires were the Multiple Sclerosis Impact Scale-29 (MSIS-29), for the assessment of the impact of MS on quality of life; the Disability of Arm, Shoulder and Hand (DASH); the Manual Ability Measure-36 (MAM-36); the ABILHAND-26 questionnaire and the Motor Activity Log (MAL), for the assessment of the function of the upper limb. The performance tests considered were: the 9 Hole Peg Test (9HPT), the handgrip strength test (HGST) and the Box & Block Test (BBT).

The MSIS-29 is a scale that assesses the impact of MS on physical and psychological function. It consists of 29 items: of these, 20 items make up the physical impact subscale, while 9 items make up the psychological impact subscale The DASH is a tool that assesses the function of the upper limb in performing activities of daily living. It consists of 38 items, organized into 3 modules: the first investigates different aspects of daily living, the second investigates work activities, and the third investigates sports/recreational activities. A higher score corresponds to greater difficulty in performing activities. The MAM-36 is a scale that investigates the ease or difficulty of per-forming common activities using the hands (e.g., eating, buttoning a button): it consists of 36 items and a higher score corresponds to greater ease in performing activities of daily living. The ABILIHAND- 26 is a questionnaire consisting of 26 items that investigate the ability to manage unimanual and bimanual activities of daily living, with the upper limbs. The MAL is a structured interview that examines how much the most affected limb is used during activities, and what the quality of movement is. The score ranges from 0 (unused limb) to a maximum of 5 (normal value). The 9HPT is a test that assesses motor performance, particularly finger dexterity. The patient must first insert and then remove 12 pegs into a perforated board as quickly as possible. The HGST is a measure of grip force and is assessed with a dynamometer: the patient is asked to squeeze the dynamometer as hard as possible and repeat the test three times. The grip strength is the average of the three tests. The BBT is an instrument that assesses unilateral manual dexterity. A wooden box divided into two compartments and 150 wooden blocks are used. The patient is asked to move as many blocks as possible from side to side, one at a time, in 60 s. A greater number of blocks moved corresponds to better manual dexterity.

The primary endpoint was improvement in manual dexterity, assessed by BBT at the end of the study. Secondary endpoints were differences from baseline in strength, fine motor skills, upper limb function and the impact of MS on quality of life.

2.4. Statistical analysis

Due to the exploratory nature of this pilot study, a sample size analysis was not performed. Data are presented as mean (± standard deviation) or median (range), as appropriate. Differences at baseline in demographic and clinical variables between the two groups were measured with the Fisher exact test (gender and age) and the Mann-Whitney *U* Test (disease duration, EDSS and BDI-II).

The primary objective of the study was to detect the effect of KT in addition to a conventional upper limb rehabilitation treatment, compared with the application of Ineslastic Tape, and to observe if it can improve dominant hand dexterity in pwMS.

The efficacy of the intervention was tested in KT-G versus IT-G by a Wilcoxon's Test. Similar analyses were performed for secondary outcomes: DASH, MAM-36, ABILHAND-26 and MAL scores for assessment of upper limb function; 9HPT and HGST scores for fine motor and strength, and MSIS-29 score for the impact of MS on quality of life. Comparison between groups, for all outcomes, was performed with the Mann-Whitney *U* Test. p values less than 0.05 were considered significant. Statistical analysis was performed with SPSS (IBM SPSS Statistics for Windows, version 25.0, Ar-monk, New York USA).

3. Results

Forty-five pwMS who regularly attend the Multiple Sclerosis Center were screened for eligibility to participate in the study. Of these, 38 subjects were found to be eligible and were divided into KT-G (n = 20) and into IT-G (n = 18) (Fig. 2). During treatment, five enrolled pwMS did not complete the rehabilitation program, one subject was no more available, and two withdrew the consent. Data of thirty patients were considered for analysis, 14 in the KT-G and 16 in the IT-G (Fig. 2).

Clinical characteristics of the pwMS who participated in the study are shown in Table 1.

KT-G and IT-G were comparable in terms of demographic and clinical characteristics at baseline (p values > .2).

Table 1
Clinical and demographical characteristics at baseline total for Kinesio Taping® Group and for Inelastic Tape Group.

		KT-G	IT-G
		N = 14	N = 16
Gender	W:M	11 : 3	14 : 2
Age, years	mean ± SD	38.50 ± 9.60	39.50 ± 8.17
EDSS	median [range]	5 [4–6]	5 [4–6]
Disease duration	mean ± SD	12.43 ± 5.1	11.32 ± 6.3
BDI-II	mean ± SD	8.5 ± 2.1	9.3 ± 1.2
9HPT	mean ± SD	32.40 ± 5.26	30.03 ± 9.38

KT-G: Kinesio Taping® group; IT-G: Inelastic Taping group; EDSS: Expanded Disability Status Scale; BDI-II: Beck Depression Inventory-II; 9HPT: 9-Hole Peg Test.

Table 2
Intragroup analysis for kinesio Taping® group and for inelastic tape group.

	KT-G	IT-G
9HPT	$p = 0.633$	$p = 0.233$
BBT	$p = 0.002$[a]	$p = 0.05$[a]
HGST	$p = 0.775$	$p = 0.129$
DASH Main	$p = 0.091$	$p = 0.119$
DASH Work Activity	$p = 0.001$[a]	$p = 0.015$[a]
DASH Sport/Leisure Time	$p = 0.001$[a]	$p = 0.317$
DASH Total	$p = 0.002$[a]	$p = 0.001$[a]
MAM-36	$p = 0.119$	$p = 0.181$
ABILHAND	$p = 0.001$[a]	$p = 0.720$
MAL	$p = 0.796$	$p = 0.126$
MSIS-29	$p = 0.214$	$p = 0.407$

KT-G: Kinesio Taping® group; IT-G: Inelastic Taping group; 9HPT: 9-Hole Peg Test; BBT: Box & Block test; HGST: Hand Grip Strength Test; DASH: Disability of the Arm, Shoulder and Hand; MAM-36: Manual Ability Measurement-36; MAL: Motor Activity Log; MSIS-29: Multiple Sclerosis Impact Scale-29.

[a] significance level for p < .05.

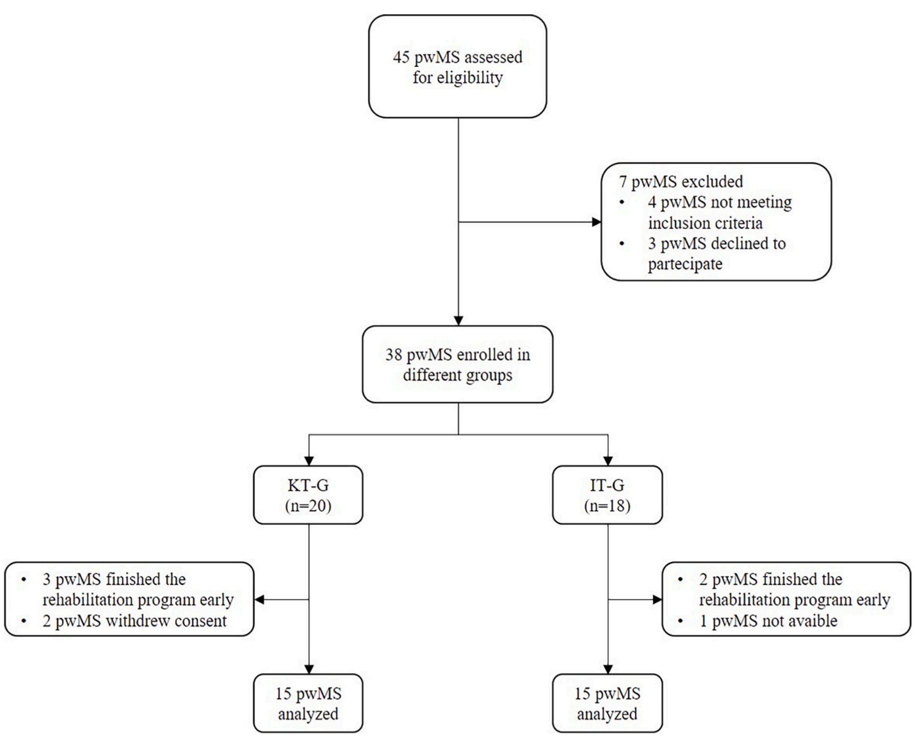

Fig. 2. Fig. 2 shows the flow chart of the study. PwMS: people with Multiple Sclerosis; KT-G: Kinesio Taping® group; IT-G: Inelastic Taping group.

Intragroup analysis showed that both groups showed significant improvement at the end of the study (Table 2). In particular, regarding pwMS treated with KT in addition to physical therapy (KT-G), analysis revealed a statistically significant improvement in BBT at the end of the treatment (p = .002), in DASH “work activity" section (p = .001), in DASH “sports/leisure activity" section (p = .001), in DASH total score (p = .002) and in the ABILHAND (p = .001) (Table 2). On the other hand, for patients treated with Inelastic taping in addition to physical therapy (IT-G), statistically significant improvement was found in BBT (p = .05), in DASH “work activity" section (p = .015) and DASH total score (p = .001) (Table 2).

Intergroup analysis between KT-G and IT-G showed statistically significant improvement in BBT (p = .001), DASH “work activity" section (p < .001), DASH “sports/leisure activity" section (p < .001) and ABILHAND (p < .001) (Fig. 3).

The other considered variables did not yield statistically significant results in the inter-group (KT-G vs IT-G) analysis; data are reported in Table 3.

Table 3
Intergroup analysis of the improvement between the two groups.

Intergroup Analysis	
9HPT	$p = 0.750$
BBT	$p = 0.001$[a]
HGST	$p = 0.269$
DASH Main	$p = 0.234$
DASH Work Activity	$p < 0.001$[a]
DASH Sport/Leisure Time	$p < 0.001$[a]
DASH Total	$p = 1.000$
MAM-36	$p = 0.089$
ABILHAND	$p = 0.001$[a]
MAL	$p = 0.114$
MSIS-29	$p = 0.082$

9HPT: 9-Hole Peg Test; BBT: Box & Block test; HGST: Hand Grip Strength Test; DASH: Disability of the Arm. Shoulder and Hand; MAM-36: Manual Ability Measurement-36; MAL: Motor Activity Log; MSIS-29: Multiple Sclerosis Impact Scale-29.

[a] significance level for p < .05.

4. Discussion

Considering the available literature, several studies have shown that in pwMS balance and walking decline earlier and more rapidly than arm and hand function (Timmermans et al., 2020). Nevertheless, both impairments – lower and upper limb – in these individuals require a

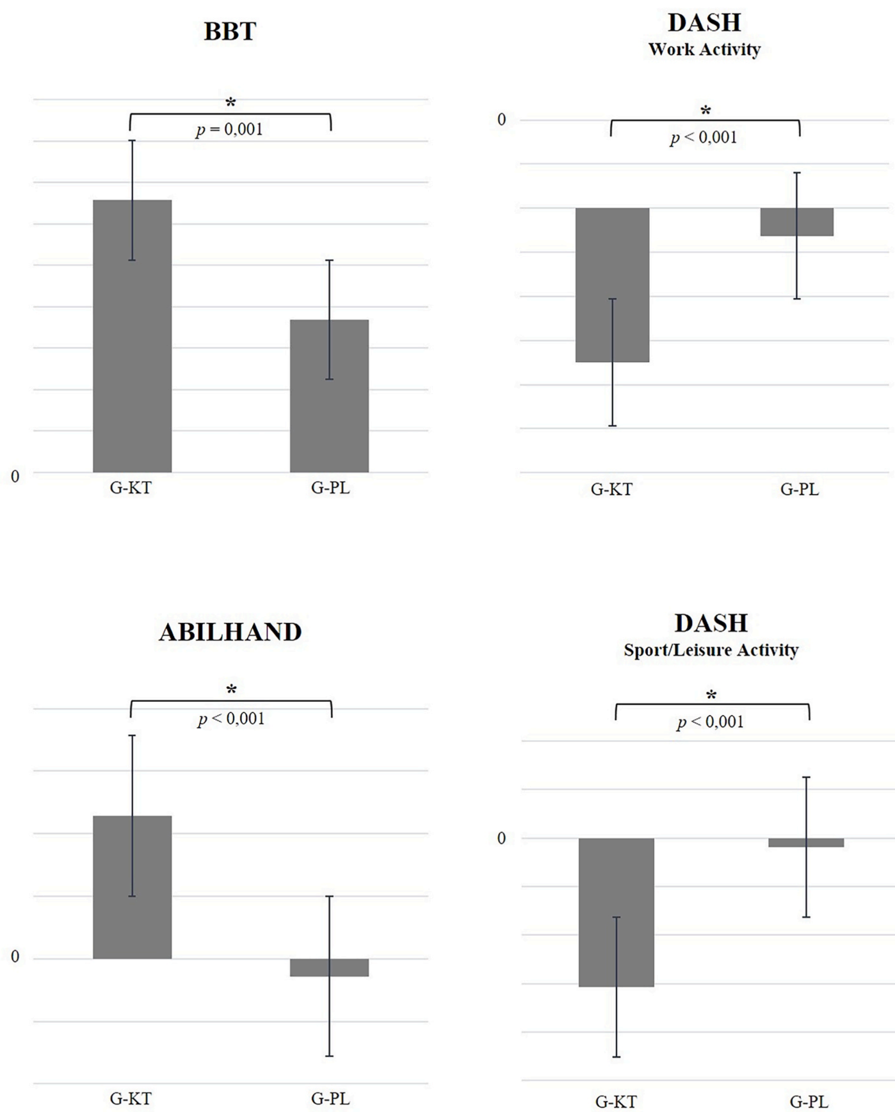

Fig. 3. Fig. 3 shows box plots representing the results of the intergroup analysis between KT-G and IT-G with regard to upper limb function and manual dexterity. KT-G: Kinesio Taping® group; IT-G: inelastic Taping group; BBT: Box & Block test; DASH: arm, shoulder and hand disabilities.

multidimensional and multidisciplinary approach to better select and apply the most appropriate and tailored pharmaceutical and rehabilitation treatment. As with balance and walking, several factors – motor reserve, assessed as premorbid physical activity, pharmacological treatment and physical therapy – play a key role (Castelli et al., 2020).

Despite the increasing focus on the MS population, there are fewer studies investigating the impact of upper limb impairments on quality of life. Hand and arm function is a factor to be considered in rehabilitation because it can impair patients' performance (both motor and cognitive) and the execution of activity daily living. In fact, manual dexterity is impaired in 75–76% of the population with MS (Johansson et al., 2007) and often individuals have bilateral deficit (Bertoni et al., 2015). Therefore, in pwMS hand deficits pose a challenge from a rehabilitation perspective. This is mainly due to the complexity of the structure, the large number of joints present, and the large number of degrees of freedom to perform a large number of functional movements that are an integral part of daily life. Most of pwMS who have sensorimotor deficits in upper limb tend to avoid using their hands (Krishnan et al., 2008), so physical therapy represents the key approach for these patients.

Data analysis showed that pwMS who participated in the study, regardless of the type of bandage used, achieved improvements in both manual dexterity, upper limb function, and the ability to manage unimanual and bimanual activities of daily living. However, the findings of the present study suggest that patients to whom KT was applied in addition to a conventional rehabilitation treatment, achieved greater benefits then the IT-G. Improvements in manual dexterity, upper limb function, unimanual and bimanual function in activities of daily living were reported. However, the improvement in motor performance was not been matched by an equivalent positive change in quality of life of pwMS involved in the study.

From results of the present study, it would be possible to speculate that the application of KT in addition to appropriate and personalized physiotherapy would be effective in improving some aspects of hand function. However, further studies are currently needed, to not only confirm or not confirm the results of this pilot study, but more importantly to enrich the evidence and the inference on this topic.

This pilot study presents some limitations. One limitation of the present research is the small sample size. Hand impairment in pwMS tends to occur rarely and in more advanced stages of the disease. However, guidelines for pilot studies indicate that for phase 2 rehabilitation pilot studies investigating motor aspects, a convenience sample of at least six participants may be sufficient initially (Dobkin, 2009). Another limitation of the study is the lack of follow-up, which makes it impossible to identify whether the motor improvement achieved is maintained in the medium and long term.

It should be considered that there are no standard protocols for rehabilitation treatment of MS. Assessment of upper limb impairment is more challenging than assessment of lower limb function: upper limb is involved in performing more complex and multidimensional daily tasks. Moreover, most of the scales and questionnaires for assessing upper limb impairment involve orthopedic conditions (more than neurological).

MS is one of the most impactful disease in term of social and National Health Service costs, with severe deterioration of patient's quality of life, caregivers burden etc. PwMS are characterized by early immunosenescence and impaired immune function, a condition close to cellular senescence in ageing. Thus, MS can be considered a pattern of premature senescence due to the involvement of immune system and lesions in the brain causing reduction of connectivity (similar to age-related gliolysis). For this reason, the role of rehabilitation and prehabilitation is crucial, and any improvement to this process should be considered to reduce muscle spasticity and prevent sarcopenia (Giovannini et al., 2021), to control pain and improve quality of life. The role of a prehabilitation is fundamental considering that upper limb impairment is detectable several months after diagnosis. This is particularly true for progressive forms of MS: in addition to pharmacological treatment, patients should begin a rehabilitation treatment after diagnosis.

Rehabilitation is one of the most important treatment in MS to improve the quality of life of individuals and decelerate/control the clinical presentation of the disease. Further studies should observe the role of KT in addition to technological rehabilitation combined with appropriate pharmacological treatment (Pau et al., 2023). There is growing scientific evidence that technological and robotic rehabilitation improves executive function and visuospatial perception (Castelli et al., 2023). The use of these technologies can improve the dual-task performance. Several studies documented that physical activity influences brain plasticity, cognitive functioning and well-being (both physical and mental component).

5. Conclusions

The present study takes into consideration problems related to upper limb function and ability in pwMS. Disabilities involving the upper limb, for pwMS, are quite disabling when considering self-sufficiency and quality of life. This deficit affects all physiological domains of these patients: motor control and dexterity, muscle strength, sensitivity, coordination, and functionality. Therefore, pharmacological treatment, physical therapy, technological rehabilitation and other supports such as KT can help the patient recover the deficit and improve the quality of life of pwMS.

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CRediT authorship contribution statement

Letizia Castelli: Writing – review & editing, Writing – original draft, Investigation. **Chiara Iacovelli:** Formal analysis, Data curation. **Claudia Loreti:** Writing – review & editing, Methodology. **Augusto Fusco:** Investigation. **Carmela Riso:** Investigation. **Lorenzo Biscotti:** Data curation. **Carlo Pozzilli:** Methodology, Conceptualization. **Luca Padua:** Visualization. **Silvia Giovannini:** Writing – original draft, Supervision.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

C.P. has served on scientific advisory boards for Novartis, Merck, Biogen, Sanofi, Genzyme, Teva, and Actelion; received funding for travel and speaker honoraria from Biogen, Teva, Sanofi Genzyme, Actelion, and Novartis; received research support from Biogen, Teva, Novartis, and Genzyme.

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