Literature Reviews

The Effects of the Feldenkrais Method in the Area of Motor Functioning – A Scoping Literature Review

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Abstract
The Feldenkrais Method is a well-known somatic method, which uses sensorimotor learning processes to improve a variety of human functioning. This scoping literature review focuses on the Feldenkrais Method used to improve motor functioning and provides an overview of the quantitative literature published in this area. Forty-one studies are included in this review, their study characteristics are summarized, and their risk of bias assessed. Overall, the existing literature makes it seem plausible that the Feldenkrais Method improves different aspects of motor functioning through principles of motor learning in different populations for different conditions and aims.

Keywords
Feldenkrais Method, Motor Functioning, Motor Learning, Coordination, Functional Movement Patterns, Functional Integration, Awareness through Movement, Balance, Range of Motion, Muscle Tone, Breathing, Posture

Please cite: (First published in the) *Feldenkrais Research Journal, volume 7*; 2025.

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1. Introduction

The Feldenkrais Method is a sensorimotor learning system and uses verbally and manually guided exploration of movements to increase people's self-awareness and to improve their movement abilities (Stephens and Hillier 2020). The Feldenkrais Method is applied in different domains, such as personal development, health, and in the performing arts (Russell 2020). The wide field of application is due to the assumption that an improvement in sensorimotor functioning also affects a person's general well-being and can help with mental complaints as well, by changing and completing a person's self-image of action (Lyttle 1997: Russell 2020). Moshe Feldenkrais (1904-1984), the founder of the Feldenkrais Method described conscious human experience as consisting of the four elements 'thinking', 'sensing', 'feeling' and 'moving', all of which are functions of the human nervous system and when a change in 'sensing' and 'moving' is achieved, the patterns of 'thinking' and 'feeling' can also be altered (Feldenkrais 2011). The Feldenkrais Method is applied in two modalities: Verbally guided group sessions called 'Awareness through Movement®' lessons and manually guided individual sessions called 'Functional Integration®' lessons.

Several reviews and overviews have been done in the past, with the earliest systematic review of a small number of studies by Ernst and Canter (2005), followed by a systematic review using Cochrane Review methodology by Hillier and Worley (2015), and a review by Stephens and Hillier (2020) which updated Hillier and Worley (2015) and provided a discussion of possible mechanisms of action. Berland et al. (2022) performed a systematic review about the Feldenkrais Method's usage as a modality within physiotherapy practice and the most recent systematic review by Martin et al. (2024) explored the potential of the Feldenkrais Method in the realm of psychiatric care. In between there have been several limited overviews of the available research literature (Buchanan 2012; Smyth 2016; Stephens 2007). The aim of this review is to give a scoping review in the area of motor functioning, since improvement of motor functioning is a primary and direct target of practicing the Feldenkrais Method and an important aspect in all domains, in which the Feldenkrais Method is applied. By providing an overview and critically assessing the risk of bias of all included studies, in addition to the existing reviews, this paper proposes to shed light on *how* the Feldenkrais Method was assessed in studies around motor functioning up to now, to report on the study characteristics, the different research designs and approaches, as well as the results. It also provides the interested reader with easy access to the findings of the available literature in this area. The four research questions for this review were:

1) What available studies exist which have assessed the effects of the Feldenkrais Method in the area of motor functioning and what were their results?
2) What were the study characteristics?
3) What was the risk of bias of each study?
4) What can be learned for future studies?

How to read this review

This review begins with some information about how it was conducted, some general characteristics of the studies (areas of research, populations, intensity and duration of interventions), the two modes of Feldenkrais Method practice, and the basis of the risk of bias assessment. Since this review gives a summary of 41 studies and is thus extensive in length and scope, the table of content facilitates reading this review and gives readers who are looking for specific studies and information a better and faster way to get oriented. For accessing all the data of the studies and to identify single studies, please see the Appendices. In the narrative description of each research study there is a description of the study purpose and design, followed by 'Findings' and 'Risk of Bias' (identified by bold subheadings). This review finishes with a discussion, including possible mechanisms of action, and recommendations for future studies.

2. Methods

Type of Review

This review can best be conceptualized as a scoping review (Arksey and O'Malley 2005). This review combines elements of a systematic review, by assessing the risk of bias, with elements of a narrative review. Its aim is to give an overview of the research literature in the context of the Feldenkrais Method used to improve motor functioning. It tracks the research development over time, describes and summarizes the different studies, critically evaluates their risk of bias and identifies research gaps in the existing literature.

Search Strategy and Selection Process

The literature research was performed using the following search engines and databases between January 2021 and December 2022: Feldenkrais Zotero Research Database, Cochrane Library, Scopus, Web of Science, Pubmed and Google Scholar. The following search words and expressions were used: FELDENKRAIS, FELDENKRAIS METHOD, ATM, AWARENESS THROUGH MOVEMENT, FI, FUNCTIONAL INTEGRATION. Additionally, all reference lists of the studies found online were cross-checked for studies not found in the online databases.

Eligibility Criteria

In this review, all studies, except single case studies, were included which quantitatively evaluated the effects of the Feldenkrais Method on an area of motor functioning as a main outcome measure and were able to be found as full articles in digital or printed format. In total, 41 studies were assessed and included in this review (Figure 1).

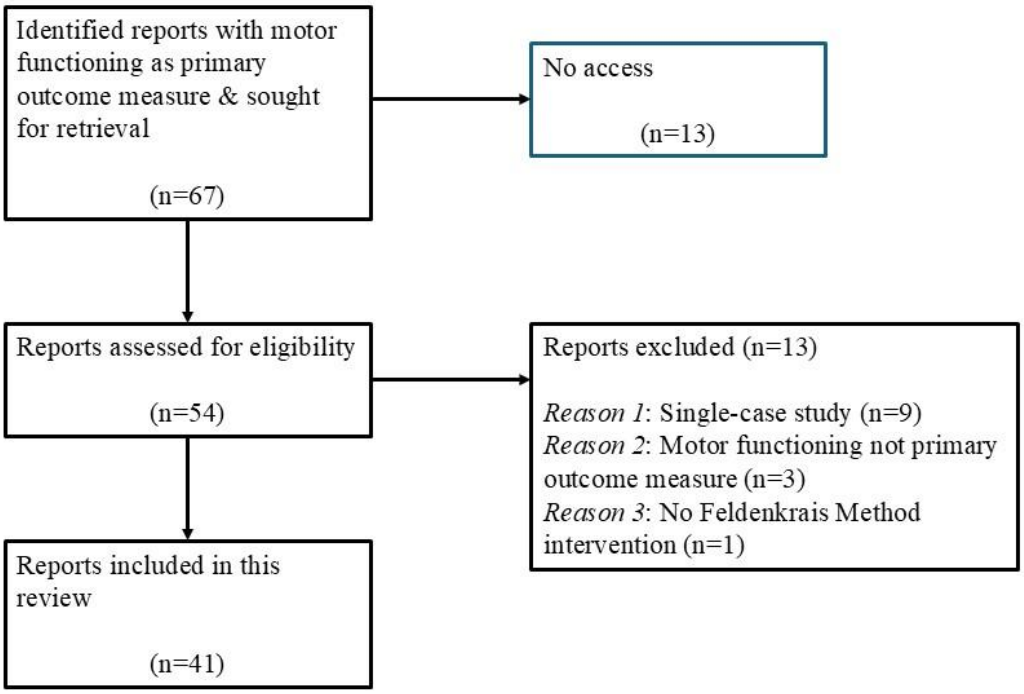

Figure 1. Flowchart for the study selection process

3. Study Characteristics

This section provides an overview of different characteristics of the included studies to get a broader picture of how the effect of the Feldenkrais Method on motor functioning was assessed. The complete table with all information can be found in Appendix 1 (Table 1, Parts 1 and 2).

Timeline Development

The first study found was published in 1977 (Gutman et al.). Whilst no studies were published in the 1980s, nine studies were performed in the 1990s and eight studies from 2000 until 2009. With 13 studies from 2010-2014 and seven studies between 2015 and 2019, the 2010s with 19 studies were the most active years in researching the Feldenkrais Method around motor functioning until now. From 2020 until the end of 2022, three studies were conducted.

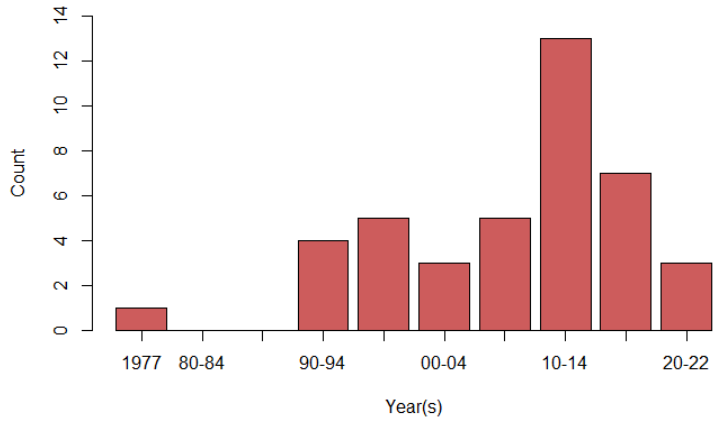

Figure 2. Timeline development of the number of publications, which studied the effects of the Feldenkrais Method on motor functioning

Overall, there is a weak trend towards an increase of the publication volume over time with the most productive period from 2010-2014 (Figure 2).

Area of Study

Most studies reviewed looked at the effect on mobility in terms of range of motion (RoM) of a body part around a joint or a fixed body point. Second, most studies looked at the effects of the Feldenkrais Method on balance, mostly with elderly people to prevent falling (summarized in Figure 3 below). In addition, two studies evaluated the effect on hand dexterity, two on breathing, and two on posture. One study looked at the change of muscle tone following a session in Functional Integration. Several studies combined measurements of different areas, for example, seven studies also included measurements on quality of life and some studies combined measurements in the category of mobility and balance. For an overview of the different outcome measurements used in the different categories, see Appendix 2.

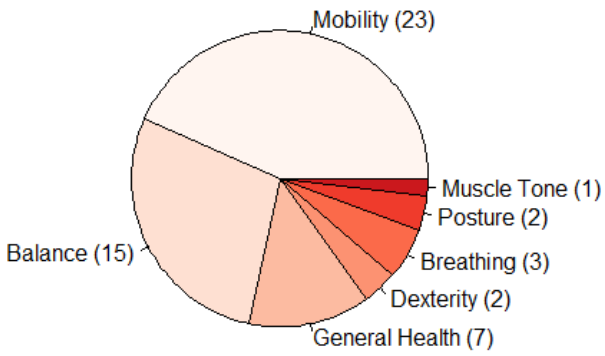

Figure 3. Areas of study

Sample Populations

The sample size range was from very small (four participants) to large (>60), with most studies having a sample size between 10 and 30 participants (Figure 4). Of the 41 studies, six studies conducted a sample size calculation. The age-distribution shows a concentration of participants between 20 and 30 years of age and over 60 years. Many studies were done with students in university contexts, however another major focus for research has been the study of effects on balance with an ageing sample population. (Cook et al. 2014; Hillier et al. 2010; Nambi et al. 2014).

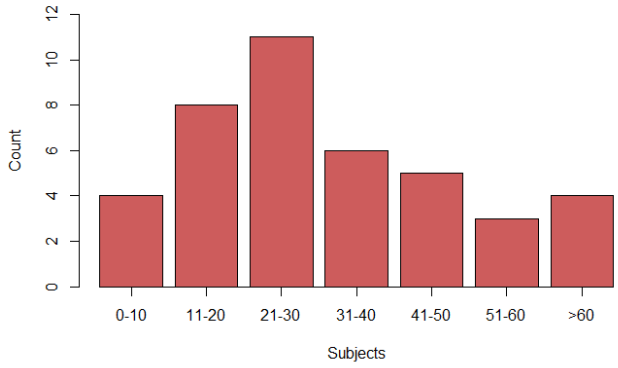

Figure 4. Distribution of the number of subjects per study

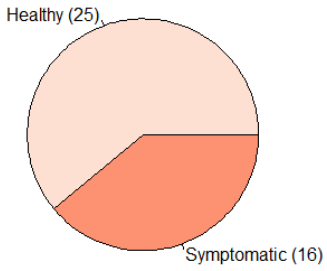

Figure 5. Frequency ratio symptomatic vs. healthy individuals

Twenty-five of 41 studies involved samples of healthy people with no illness or disability, while 16 studies had samples of symptomatic individuals (Figure 5). Thirty-two of the 41 studies reported a mean age number and studies who reported a median figure were not included in the histogram (Figure 6).

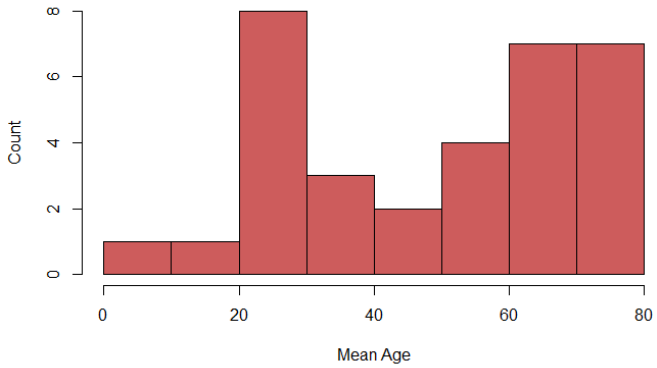

Figure 6. Age distribution of the different sample populations

Duration, Sessions, and Intensity

This section provides information about the duration of the interventions, the number of sessions per study and how often per week a session was performed. This information gives orientation for researchers who are planning a future study and are asking themselves how long and how intense the intervention should be and what has been studied up to now (Figure 7).

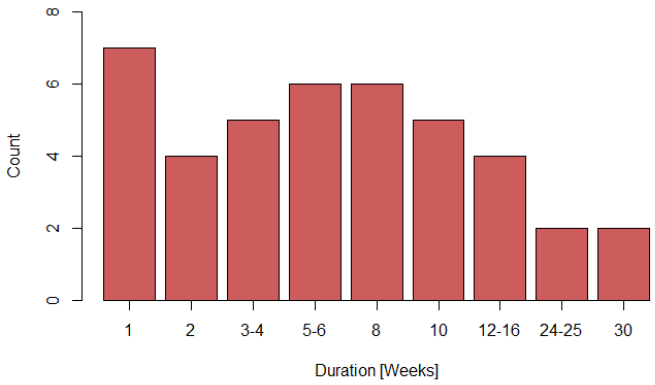

Figure 7. Overview of study durations

The study duration ranged from one week to 30 weeks with most studies looking at sessions conducted within one week. When looking at the number of sessions (Figure 8), most studies looked at the effect of 7-8 sessions, but also seven (7) single-session studies were conducted. The intensity (sessions/week) was low in most studies, with 1-2 sessions per week in 30 of 39 studies (two studies did not include information on session-intensity) (Figure 9).

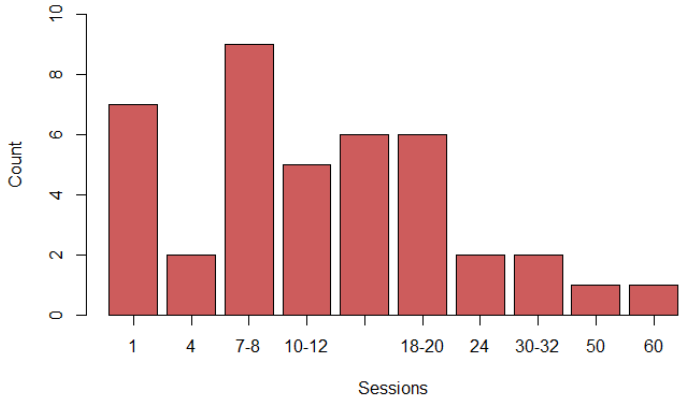

Figure 8. Number of studies showing different numbers of practice sessions

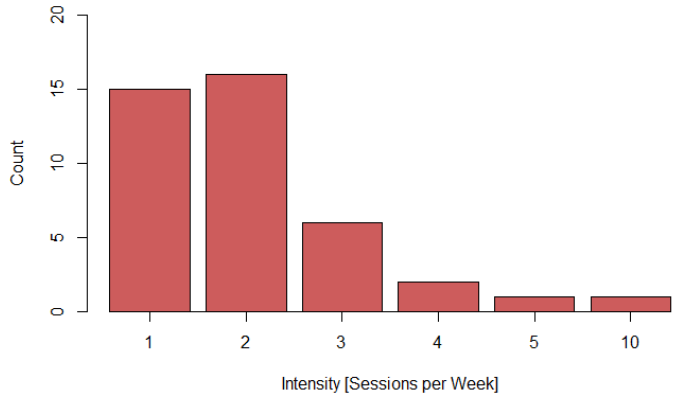

Figure 9. Overview of the intensity of practice per study, measured as sessions per week

Awareness Through Movement or Functional Integration

Even though the Feldenkrais Method consists of two parallel modalities, individual sessions in Functional Integration and group sessions in Awareness Through Movement, only two of the 41 studies looked at the effectiveness of Functional Integration. This means that studies which investigated the effect of personal sessions of the Feldenkrais Method to improve motor functioning are largely underrepresented in the literature.

Follow up and Sample Size Calculation

Two of the 41 studies included follow-up measurements (Causby et al. 2016; Kang et al. 2021) and six of the 41 studies performed a sample size calculation prior to the study.

4. Risk of Bias Assessment

Risk of bias of all the studies was assessed using several different methodologies. These were:

1) The 2011 Oxford CEBM Levels of Evidence,
2) PEDro-Scale for randomized controlled trials,
3) The ROBINS-I assessment tool for non-randomized studies of interventions.

The Oxford CEBM levels of evidence range from level 1-5 (2016). Since there were no systematic reviews (level 1) and no articles about mechanistic reasoning included (level 5), the studies were graded from level 2 to level 4. Randomized controlled studies are classified as level 2, non-randomized controlled studies as level 3 and non-controlled studies as level 4. For randomized controlled studies (level 2), the PEDro-Scale (Hegenscheidt et al. 2010) was used to further assess their quality and for non-randomized controlled studies, the ROBINS-I

assessment tool was used to evaluate the risk of bias (www.riskofbias.info, n.d.) A decision tree was established to make the different studies comparable in their risk of bias, which led to the creation of five different categories of risk of bias: 'Very low', 'low', 'moderate', 'serious' and 'critical' (Figure 10). Randomized controlled studies with a PEDro-Score of 7 or higher were given the label 'very low' and the ones with a PEDro-Score lower than 7 were given the label 'low'. The cut-off score of 7 for a 'very low' risk of bias was chosen, because it is suggested in the literature that studies with a PEDro-Score of 6-8 describe a good-quality study (Maher et al. 2003). Non-randomized controlled studies could, depending on their ROBINS-I assessment, be classified as low, moderate, serious or critical, according to the ROBINS-I-Tool assessment (Sterne et al. 2016). Non-controlled studies were given the label 'critical'. The PEDro-Score of each study can be found in Table 1, Part 2 in Appendix 1.

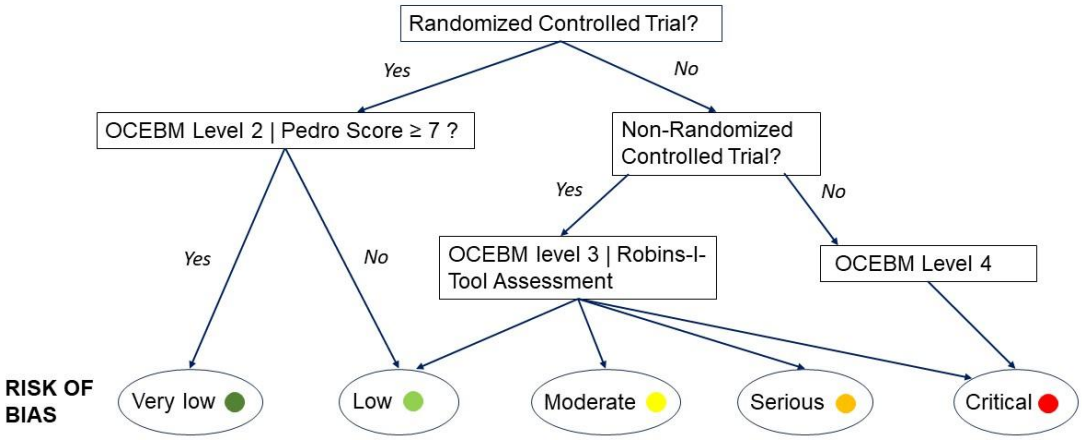

Figure 10. Risk of bias decision tree

The quality of the studies in terms of risk of bias, ranged from 'very low' to 'critical'. Figures 11 and 12 show the number of the different studies in each risk of bias category for the OCEBM classification and the categories defined by the decision tree. In the 'Summary' section, the risk of bias category is added at the end of each study description, for the reader to critically put into perspective the results of a study. For one study (Buchanan and Vardaxis 2000), it was not possible to assess its risk of bias, due to lack of information.

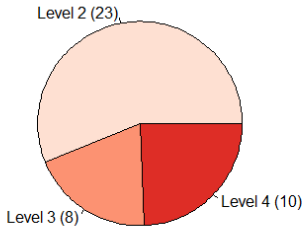

Figure 11. Pie chart of levels of evidence by OCEBM

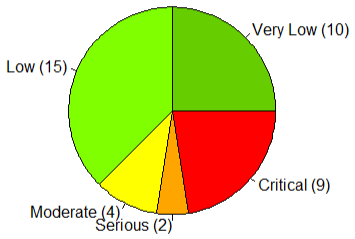

Figure 12. Pie chart levels of evidence by decision tree

5. Summary of the Studies

The aim of this section is to give a comprehensive overview and to present the studies and their results that assessed the area of motor functioning. To improve readability, this section is subdivided into the following sub-categories: ‘Mobility and Balance’, ‘Posture’, ‘Hand Dexterity’, ‘Breathing’, ‘Muscle Tone’ and ‘General Health Assessment’. Within each sub-category the studies are presented and described along with their year of publication.

5.1 Mobility and Balance

Out of the studies included for this review, the vast majority, 22 out of 41 studies, investigated the effect of Feldenkrais Awareness through Movement (ATM) lessons on some aspects of mobility and balance.

The first study, done by **Gutman et al. (1977)** was a non-randomized controlled trial with a healthy sample of 38 ageing participants, which compared the effects of a six-week Feldenkrais Method lesson program (three hours per week) to no intervention and to a conventional exercise program for the elderly. **Findings:** There were no significant differences between the groups, but the Feldenkrais Method lesson group improved in all measures, which included rotational flexibility, balance, self-perceived health status and number of body parts painful or difficult to move. **Risk of bias:** Serious ●

In **1991, Brown and Kegerreis** performed a randomized-controlled study to test the difference of one Awareness Through Movement lesson on a flexion task with 21 young and pain free participants. Elements of kinesthetic awareness, imagery and visualization, as well as cues pertaining to lightness, comfort and ease were excluded in the control group and the lesson only included movement instructions. Electromyographic activity of the flexor and extensor muscles along with perceived level of effort were compared pre- to post-intervention in both groups. **Findings:** No significant changes were found between the groups, but within both groups there

were significant changes in flexor EMG activity and in perceived exertion ratings. This study suggests the Feldenkrais Method may achieve its intended goal of facilitating movement with less effort and greater flexibility. It also suggests that the Feldenkrais Method may produce a perceptual recognition of a physiological change in muscular activity that is not the direct result of the use of suggestion, imagery, or visualization. A change was produced in the amount of muscular activity required to perform a movement task. **Risk of bias:** Low ●

A randomized controlled study done by **Ruth and Kegerreis (1992)** looked at the effect of one single Awareness Through Movement lesson in 30 healthy participants on the range of motion of active neck and head movements and the accompanying perceived effort compared to a control group with no intervention. **Findings:** The experimental group showed significant improvements in range of motion and perceived effort, compared to the control group. This study provides data that support assertions that immediate physical and perceptual changes can be affected with the use of Feldenkrais Method Awareness Through Movement sequences. **Risk of bias:** Low ●

A randomized controlled study by **Chinn et al. (1994)** looked at the effect of a single Feldenkrais Method Awareness Through Movement intervention on a functional reach task on 23 participants with upper back, neck, or shoulder discomfort. In the functional reach task, subjects were lying supine and reaching up along a wall. Participants rated the level of perceived exertion pre- and post-treatment on a visual analog scale (VAS). The control group followed a sham intervention, consisting of tape-recorded instructions of general upper body exercises. **Findings:** Results showed significant reduction in exertion for the Awareness Through Movement group and no significant difference in exertion for the sham treatment group. In both groups, there were no significant increases in the functional reach measurement. The authors concluded that a single Feldenkrais Method intervention produced positive effects in participants with upper back, neck and/or shoulder discomfort. **Risk of bias:** Low ●

Hall et al. (1994) compared in a randomized controlled trial with 60 participants the effects of Feldenkrais Method Awareness Through Movement group classes to Tai Chi classes, and to a no intervention control group on balance in healthy older women. The Feldenkrais Method and Tai Chi group both attended a total of 32 sessions, with two sessions per week for 16 weeks. **Findings:** The Feldenkrais Method group improved significantly in the Falls Efficacy Scale (FES), the Berg Balance Test, the Timed Up and Go Test, and the Pro Balance Master Test. There were no significant changes in the control group with no intervention. The Tai Chi group improved significantly in several outcome measurements as well. The improvement of movement times in the Pro Balance Test for the Feldenkrais Method group indicates that participants were quicker to respond and correct their balance, once they are outside their base of support. According to the authors, both Tai Chi and Feldenkrais Method classes are suitable to promote health and balance in this age group. **Risk of bias:** Low ●

Brown et al. (1996) evaluated the effect of Awareness Through Movement lessons on the mobility of a healthy elderly sample with 23 participants in a non-randomized controlled study. The experimental group took part in three Awareness Through Movement lessons per week for six weeks. The control group received no intervention. **Findings:** The Awareness Through Movement group showed significant improvements in right ankle dorsiflexion and in the Timed Up and Go test. No significant improvements were found in the functional reach test and other active range of motion measurements. Whilst participants did not show a significant change in the Dartmouth COOP measures of perceived functioning and health, 10 out of 12 participants showed improvement in their scores from pre-exercise to post-exercise. **Risk of bias:** Moderate ●

James et al. (1998) investigated the effects of a Feldenkrais Method Awareness Through Movement program and relaxation procedures on hamstring length measured by knee extension. In a randomized controlled trial, 48 healthy undergraduate students were randomly allocated to either Feldenkrais Method lessons, relaxation, or a control group with no intervention. Participants in the Feldenkrais Method and relaxation group participated in four 45-minute lessons over a two-week period. **Findings:** No significant effects were found between groups and even though there was a trend present for the Feldenkrais Method group for an increase in hamstring length, the degree of change was not statistically significant. The authors questioned whether a test like the active knee extension test, which measures hamstring length in relative isolation is an appropriate way to assess the effectiveness of the Feldenkrais Method, since it is suggested that the Feldenkrais Method improves functional movement patterns, rather than single-joint action. **Risk of bias:** Very low ●

In a similar study, **Hopper et al. (1999)** measured the effect of a single Awareness Through Movement lesson for participants, with and without prior experience of the Feldenkrais Method, as well as the effect of four lessons over a two-week period on hamstring length, flexibility, and perceived exertion. In studying the effect of a single Feldenkrais Method lesson for those with no prior experience, 75 healthy participants were randomly allocated to either the Feldenkrais Method group or the control group. The participants in the control group listened to relaxing music for 45-minutes, whereas the Feldenkrais Method group performed the lesson “Lengthening the hamstrings and spine” by Frank Wildman. Findings: Participants in the Feldenkrais Method group improved significantly in sit and reach measurements after one lesson, but their counterparts in the control group did not. No significant effects were found in perceived exertion and in the active knee extension test after one lesson with no prior experience. After four lessons, both the experimental and control group showed significant improvements in the sit and reach measurements over time. For perceived exertion, the Feldenkrais Method group experienced significantly less exertion during the sit and reach test across all measurement times. No significant differences between groups were found for the modified active knee extension measurements. The authors argued that their research provides

support that the Feldenkrais Method works by providing alternative motor patterns (Bate 1994) and new methods of muscle recruitment to improve functional movements. **Risk of bias:** Low ●

Buchanan and Vardaxis (2000) measured the effects of eight Feldenkrais Awareness Through Movement group lessons over two weeks on balance during standing, in a non-randomized controlled design. The sample consisted of 20 adult, injury-free women. An AMTI force plate was used to measure several characteristics in standing. **Findings:** The center of pressure distribution (COP) changed within the Feldenkrais Method group from elliptical to circular. This was achieved by decreasing the extreme excursions in the medial-lateral and anterior-posterior direction in sway, thus suggesting that the Feldenkrais Method can improve balance and postural control in standing. **Risk of bias:** Not enough information

To study the effect of sensory-imagery in a Feldenkrais Method Awareness through Movement lesson on mobility, **Dunn and Rogers (2000)** had 12 healthy participants listen to a 30-minute guided sensory-imagery lesson, in which only one side of the body, the left side was imagined to be brushed with a soft bristle over different body segments and the right side served as a control. To test the differences between the two sides, participants were asked to perform a sit and reach test, with one foot's sole resting at the inside of the opposite knee and the other leg stretched out against the upright side of a box. Like this, the forward-bending mobility was measured for each side. **Findings:** Results showed that the side that was actively imagined during the sensory exercise, felt lighter and longer for most participants after the guided lesson (two participants reported that the opposite side from that which they worked on felt lighter and longer). For 10 out of 12 participants there was a significant increase in forward flexion on that side. The authors concluded that exercises directed to sensory responses could be beneficial for the enhancement of functional movement. **Risk of bias:** Low ●

Stephens et al. (2005) studied the effect of 10 Awareness Through Movement lessons undertaken within two days, on coordination, economy of movement and general health in a healthy elderly population with 31 participants. The study was a non-randomized controlled study (using a convenience sample) and the participants were between the ages 68 and 89 and healthy. There was no intervention in the control group. In their data analysis, Stephens et al. divided the participants into two groups, one "young/old" (under 78 years old) and an "old/old" group (78 and over). **Findings:** In the results of the coordination task (supine to stand), they observed significant changes as an interaction of group x age x time. In both measures, movement time and movement units, there was a significant decrease in the younger group and an increase in the older group. This result is quite puzzling, since both age groups in the experimental group reported that the supine to stand task became easier after the Awareness Through Movement lessons. The authors suggest that the older group realized that they could move more slowly and carefully in a complex movement, that is unfamiliar for most 80-year-olds. No significant changes were observed in the economy of movement task. There

was a significant improvement in the vitality and mental health scores in the experimental group. **Risk of bias:** Moderate ●

Stephens et al. (2006) conducted a randomized controlled study, where they measured the effect of Awareness Through Movement lessons on an active knee extension test in a healthy sample of 33 individuals. There was no intervention in the control group. Participants in the Awareness Through Movement lesson group were asked to perform a 15-minute Awareness Through Movement session five times a week during a three-week period, guided by an audiotaped Awareness Through Movement lesson sequence. The lesson consisted of variations of movements, requiring lengthening of the hamstring muscle in different postural configurations. **Findings:** Even though the effectively practiced session ranged between 8 and 15 minutes and the total minutes of practice ranged from 80 to 300, a regression analysis showed no significant effect on hamstring length change in the Awareness Through Movement group as a result of number of practice sessions, total number of practiced minutes or the amount of delay between the last practice session and the final measurement. Overall, the Awareness Through Movement group gained significantly more hamstring muscle length, compared to the control group, with a mean number of 11 sessions and 177 practiced minutes. **Risk of bias:** Low ●

In a large randomized controlled study with 55 participants, **Vrantsidis et al. (2009)** studied the effectiveness and acceptability of Feldenkrais Method Awareness Through Movement lessons to improve balance in a healthy elderly sample. The intervention consisted of a twice-weekly group class over eight weeks. There was no intervention in the control group. The Awareness Through Movement classes were part of the “Getting Grounded Gracefully” program, which is designed to specifically improve balance in a variety of postural configurations. **Findings:** There was a significant change in the Modified Falls Efficacy Scale for the intervention group, a significant improvement in gait speed and a non-significant improvement in the timed up-and-go test. These results all suggest some improvement in dynamical balance in the intervention group compared to the control group. This is one of the few studies which conducted a sample size calculation prior to the study and who blinded assessors. The authors conclude that even though the study was underpowered to detect a clinically meaningful change, these results and the positive participant feedback on the Feldenkrais Method classes warrant further research on the Feldenkrais Method to improve function and balance in older people. **Risk of bias:** Very Low ●

In **2010, Hillier et al.** tested the effects of Feldenkrais Method classes compared to a control group, who participated in a generic balance class. Twenty-two individuals of a healthy, ageing population self-selected one of the two classes, without being aware of which class they chose. The study was described as a pseudo-randomized controlled trial. Both classes were held once per week for eight weeks. **Findings:** The results showed significant improvements in both classes for the Patient Specific Functional Scale (PSFS) and the Functional Reach Test (FRT). Only the Feldenkrais Method group improved significantly in the single leg stance test (SLS).

Neither the Feldenkrais Method group, nor the balance class reached significance for the Timed Up-and-Go test and the Walk on the Floor with Eyes Closed (WOFEC) measurement. **Risk of bias:** Low ●

In a similar, randomized controlled study in **2010, Ullmann et al.** studied the effects of a five-week (60 min, three times per week) Feldenkrais Method lesson program on mobility and balance in a healthy, ageing sample with 47 participants (mean age 76 years). There was no intervention in the control group. The outcome measures were balance (tandem stand), mobility (timed up-and-go), gait characteristics, balance confidence and fear of falling. **Findings:** Balance and mobility increased significantly in the Feldenkrais Method group, and fear of falling decreased significantly. The authors concluded that the Feldenkrais Method exercises offer an effective way to improve balance and mobility in older adults. **Risk of bias:** Low ●

Heister (2010) looked at the effects of Awareness Through Movement lessons on different samples of athletes, including 30 individuals. It was a pre-post study design with no control group. The three different subgroups were ageing athletes above 30 years of age, professional athletes consisting of girls between 10-14 years who train in gymnastics for 15-25 hours a week, and a group of disabled athletes with impaired vision. The intervention took place during 2 x 1 hours for four weeks. Outcome measure was a self-assessment questionnaire, asking about the self-perception during a single-leg stance with eyes closed on each leg. **Findings:** The author reported significant improvements in the feeling of stability, shoulder tension and freedom of breath in all subgroups and in the number of equalizing movements in most subgroups. **Risk of bias:** Critical ●

Connors et al. (2011) also studied the effects of a Feldenkrais Method program to improve balance in older adults in a non-randomized controlled study with 63 participants. The Awareness Through Movement classes of the “Getting Grounded Gracefully” program were conducted twice a week for one hour for 10 weeks. There was no intervention for the control group. **Findings:** The Feldenkrais Method group showed significant improvements at re-testing on all measures, including the activities specific balance confidence questionnaire (ABC), the Four-Square Step Test (FSST) and self-selected gait speed. The Feldenkrais Method class was thought by the authors to enable a freer gait style, resulting from improved balance confidence due to greater intersegmental control between the lower limbs, pelvis, trunk, and head. **Risk of bias:** Moderate ●

Bellafiore et al. (2012) looked at the influence of Feldenkrais Method classes on spine health in professional orchestral musicians in a randomized controlled trial with a small sample (n=17). There was no intervention in the control group. The experimental group took part in two hours of Awareness Through Movement classes per week for four weeks. **Findings:** There was no significant effect detected on muscle fitness and flexibility of the spine, measured by a sit and reach and trunk lift test. There was a positive trend in both measures in participants in the Feldenkrais Method group and a slight worsening in the control group, suggesting that the

Awareness Through Movement classes prevented a worsening of these abilities. The authors mentioned that the absence of a significant effect might be due to the small sample size and the brief length of intervention. **Risk of bias:** Low ●

In a 2012 study, **Khurana et al.** investigated the effect of Feldenkrais Method group classes on hamstring lengthening in a non-controlled study with young, healthy individuals (n=25). The study mentions that Feldenkrais Method classes were given for 15 consecutive days, but no information about the duration of the exercises is given in the text. **Findings:** Even though the study mentions an angle increase in the 90-90 Single Leg Raise test (SLR), no information is given about whether this increase was significant or clinically meaningful. **Risk of bias:** Critical ●

A randomized controlled trial by **Bipinbhai (2013)** compared the effectiveness of the Alexander Technique, the Feldenkrais Method, and conventional balance exercises to improve balance in older adults with balance problems. Each of the three groups consisted of 15 individuals and received lessons for five days in a week for one month. **Findings:** The Feldenkrais Method group improved significantly in the assessment with the Berg Balance Scale (BBS) and the Functional Reach Test (FRT) in standing. Compared to the conventional exercises, the Feldenkrais Method group improved balance significantly more, when assessed with the FRT in standing and the BBS. The study overall suggests that all three groups showed significant improvement in some balance measures. Between group comparison suggests that the Alexander Technique group and the Feldenkrais Method group improved balance more than undertaking conventional exercises. While comparing the Feldenkrais Method group and the Alexander Technique group, there was no significant difference in improving the balance in older adults. **Risk of bias:** Very low ●

In **2013, Webb et al.** investigated the effect of Feldenkrais Method Awareness Through Movement classes on people (n=15) with osteoarthritis. The study was a prospective study with pre- and post-measure, but no control group. The classes were held twice per week for 30 weeks. **Findings:** The participants improved in the Four-Square Step Test (4SST) and kinematic analysis showed a decreased anterior pelvic tilt, which reduced the forward inclination of the trunk and reduced loads and the low back when walking. A major limitation of the study was that there was no control group and that no information is given as to whether the results were significant. **Risk of bias:** Critical ●

Cook et al. (2014) performed a non-randomized controlled study, to investigate the effect of a Feldenkrais Method intervention on balance and gait in healthy women between the ages of 40 and 80 (n=46). The intervention was short, with one to two classes during five consecutive days. **Findings:** The results showed significant improvements in quality of life, balance confidence, and gait characteristics, but there were no improvements in a two-footed balance test with eyes closed. The authors concluded that since it is not likely that physical properties of the muscles

and tendons changed during five days of intervention, that the effects were due to changes in neurological control of the muscles. **Risk of bias:** Serious 🟠

A randomized controlled study by **Nambi et al. (2014)** compared the effects of Feldenkrais Method lessons and Pilates classes to a control group in an ambulatory geriatric population (n=60). Each group had 20 participants and all groups completed six weeks of intervention with three sessions per week. The control group received instructions to warm up, walk for 12 minutes and cool down afterwards. The outcome measurements included the Functional Reach Test (FRT), Timed Up-and-Go test (TUG) and dynamic gait index for functional balance. Quality of life was also measured at baseline and after six weeks of training. **Findings:** The results showed significant improvement in functional balance and quality of life, both in the Feldenkrais Method and the Pilates group, but not in the control group. The authors concluded that both Pilates classes and Feldenkrais Method lessons are effective in improving functional balance and decreasing propensity to fall in an ambulatory, geriatric population. **Risk of bias:** Very low 🟢

Maddali-Bongi et al. (2017) performed a pilot study to assess the effects of Feldenkrais Method group sessions on patients with Ankylosing Spondylitis. There was no control group and only descriptive statistics was performed. Ten patients visited a total of 10 sessions, twice per week. Additionally, patient-tailored home exercises, chosen by the therapist, were performed daily for 30 minutes. **Findings:** The study results showed improvements in pain, fatigue, global health status and lumbar and cervical mobility. The authors conclude that the results are promising, but should be validated with larger, randomized controlled studies. **Risk of bias:** Critical 🔴

Palmer (2017) studied the effects of Feldenkrais Method lessons to improve healthy older adults' awareness, comfort, and function. The study design was a non-randomized controlled trial with blinded assessors and 87 participants. To compare the effect of lesson intensity, the experimental group was divided into two subgroups, of which one took 12 lessons in six weeks and the other in 12 weeks. There was no intervention in the control group. Outcome measures included Tandem Stance, Functional Reach Test, Timed Up and Go and the OPTIMAL survey for self-reported changes in activities. The analysis method allowed for correlation analysis between number of attended lessons and outcome measurements, since the number of visited lessons differed individually (with a minimum of eight lessons). **Findings:** Results showed a significant correlation between the number of lessons visited and the improvements in Functional Reach and in the OPTIMAL survey for the experimental group. There was also a significant improvement compared to the control group in the OPTIMAL survey for self-reported changes in activities, but there was no significant difference between the experimental and control group in the other outcome measures. Also, it seemed that it is not the density of the sessions which is important, but the total number of visited lessons, since the six and the 12-weeks group experienced similar improvements. **Risk of bias:** Moderate 🟡

In a randomized controlled trial, **Torres-Unda et al. (2017)** investigated whether Feldenkrais Method group classes improve functioning and body balance in middle-aged people with intellectual disability (ID) (n=32). The experimental group received 30 Awareness Through Movement lessons, with one lesson per week while the control group did not receive any movement intervention. Physical functioning was assessed with the Short Physical Performance Battery (SPPB) and balance by a stabilometry test. The SPPB is a composite score of performance (0–12) based on three functional tasks: walking speed, chair rise test, and standing balance (Guralnik et al. 1994). **Findings:** After 30 Awareness Through Movement classes, the experimental group significantly improved their chair rise test score, their total SPPB score, and significantly reduced their sway area in the stabilometric test. There was also a significant interaction between group and time for the SPPB total score, meaning that individuals in the experimental group improved their functioning more than controls. The improvement of the SPPB total score for the experimental group was considered clinically meaningful. Overall, these findings indicate that individuals with intellectual disability significantly improved their physical functioning by participating in a Feldenkrais Method intervention and that the Feldenkrais Method could be a good tool for the prevention of loss of functioning and body balance in middle-aged individuals with intellectual disability. **Risk of bias:** Low ●

5.1.1 Individuals with neurological conditions

Seven studies within the category of mobility and balance were conducted with symptomatic individuals having a neurological condition.

In a multiple case study, **Stephens et al. (1999)** looked at the effect of 10 Awareness Through Movement classes over 10 weeks on four women with multiple sclerosis (MS). Outcome measures included the fatigue severity scale, index of wellbeing, motion analysis of gait and supine to stand task. **Findings:** The primary outcome result was an increased sense of wellbeing, and improvement of balance and control of movement. **Risk of bias:** Critical ●

In a randomized controlled trial with a crossover design, **Johnson et al. (1999)** studied the effect of eight individual Functional Integration (FI) sessions on 20 individuals with multiple sclerosis. One half of the group received Functional Integration sessions, while the other half received a sham intervention, where the practitioner moved clockwise around the table and lightly laid his hands on different body parts. The sham intervention was designed to control for effects of attention, touching and the personality of the practitioner. When asking the participants whether they noticed the difference between the two interventions, all participants reported that they noticed a difference and reported the Feldenkrais Method sessions as being more effective. The outcome measures included tests for hand dexterity, MS performance scales and questionnaires on psychological variables such as perceived stress, anxiety, and depression. **Findings:** The results showed no effect of the Feldenkrais Method and sham sessions on MS symptoms, levels of functional ability, and upper extremity performance. There was a significant

difference for perceived stress and lowered anxiety after Feldenkrais Method sessions, but not after the sham intervention. The authors conclude that the greatest treatment effect was on psychological variables and that the importance of this cannot be underestimated, since stress has been implicated in both onset and disease activity in MS. **Risk of bias:** Very low ●

Another study by **Stephens et al. (2001)** investigated the effect of Awareness Through Movement classes on people with MS in a randomized controlled design with a small sample size (n=12). While the Awareness Through Movement group participated in eight Awareness Through Movement classes, with a total of 20 hours during a 10-week period, the control group participated in four 90 minute educational classes. **Findings:** The results showed a significant improvement in the Feldenkrais Method group for balance and balance confidence. The authors suggest that Awareness Through Movement classes incorporate basic principles of balance training and combine it with kinaesthetically based, exploratory movements. **Risk of bias:** Low ●

A randomized controlled study by **Teixeira-Machado et al. (2017)** looked at the effects of 50 sessions, done twice per week, in Feldenkrais Awareness through Movement classes to improve motor functionality in Parkinson's disease (PD). Thirty participants with PD were divided into an experimental and a control group. The control group received educational lectures during the experimental period. Outcome Measurements included a Timed-up-and-go test, rollover task, 360-Degree turn-in-place task, functional-reach test, sitting-and-standing test, Berg balance scale and hip-flexion strength test. **Findings:** The Feldenkrais Method Group significantly improved in all measures when compared to before treatment, but also when compared to the control group. The authors conclude that the Feldenkrais Method helps patients with PD to improve motor functioning, without neglecting the emotional wellbeing. **Risk of Bias:** Very low ●

A non-controlled study by **Kang et al. (2021)** analyzed the effect of a dance intervention using the Feldenkrais Method on motor and non-motor symptoms in nine participants with Parkinson's Disease (PD). The participants visited an Awareness Through Movement class once per week during a six-month period. This is the only study analyzed for this paper, which conducted a follow-up measurement after six months of the end of the intervention. **Findings:** The results showed significant improvement in gait velocity and step length between three and six months, but then worsened again until the follow up measurement. Mobility, as measured by the Tinetti scale, decreased significantly during the intervention period. The Parkinson's Disease Quality of Life test showed a significant improvement after six months, but after 12 months, there was no more effect being observable. The authors discuss several study limitations, such as small sample size, no correction for type 1 error, and no control group. **Risk of bias:** Critical ●

A two-armed, randomized controlled pilot study, by **Serrada et al. (2022)** studied whether body awareness training with the Feldenkrais Method can improve recovery following a stroke. Participants (n=20) had a diagnosis of a stroke (three months to six years ago) and were

randomly assigned to either the experimental or control group. The experimental group took part in two face-to-face lessons of 45-minutes each week for 10 weeks while the control group listened to recordings in their home with the same lessons. In comparison to the home-based group, the class-based group reported greater acceptance and perceived effects, as well as the likelihood to continue practicing the Feldenkrais Method after program completion. The importance of the therapist and a connection with others for feedback, company and socialization, comparison, and motivation were of utmost importance for the class-based group. **Findings:** Pre- and post-intervention measures showed significant improvements in the class-based group compared to the home-based group in arm and leg motor impairment scales, body awareness and quality of life. The improvements in arm and leg motor functioning and quality of life are clinically meaningful according to the authors. The home group took longer to complete (13 – 25 weeks) and had reduced adherence, perhaps reflecting the effect of peer-group versus individual motivation. Participants drop-out and withdrawal rate although low and equally distributed between groups was an issue. The important clinical messages were reported as the following: 1) Body awareness classes are feasible and safe for people in chronic phase after a stroke. 2) Functional movements and directed attention develop a better understanding of the 'new' body after stroke. 3) Improved body awareness may provide benefits in recovery after stroke. 4) Peer support and group interaction may be beneficial for recovery. **Risk of bias:** Low ●

5.2 Dexterity

Two studies were performed investigating the effects of Feldenkrais Awareness Through Movement lessons on hand dexterity.

A very well-designed, double-blinded randomized controlled study with healthy students (n=29) by **Bitter et al. (2011)** evaluated the effect of a single, two-hour, Feldenkrais Method sensory awareness lesson for hand dexterity. The outcome measures were the Purdue Pegboard Test, a grip-lift manipulandum task, and perceived changes using a questionnaire designed for the study. The students were randomly assigned to one of three groups: 1) Feldenkrais Method lesson with the dominant hand; 2) Feldenkrais Method lesson with the non-dominant hand; and 3) Sham intervention in the form of progressive muscle relaxation. A sample size calculation was performed in order to have enough participants in each group to detect a meaningful effect in the grip force task. **Findings:** The results showed significant improvements in the Purdue Pegboard Test for the experimental group compared to the control groups. For the grip-lift task, only the maximum grip force to hold the manipulandum decreased significantly in the dominant-hand group compared to the non-dominant and control group. All participants in the dominant and non-dominant hand group reported that the intervention hand felt different after the lesson compared to before the lesson and felt different to the hand that didn't receive the sensory attention. The authors concluded that a single sensory-awareness lesson improves hand dexterity in healthy adults, making it a useful intervention for populations requiring high

dexterity, such as musicians and medical professionals who require high hand dexterity. **Risk of bias:** Very Low ●

In another randomised controlled trial, **Causby et al. (2016)** investigated the effect of additional sensory awareness training and motor practice for learning scalpel skills in podiatry students. Forty-four participants were randomly assigned to three groups; 1) a sensory awareness group, receiving one 40-minute Feldenkrais Method session and practicing two audio recordings at home, one of which targeted the dominant hand. 2) a motor practice group, practicing scalpel holding and, 3) a control group, who received the standard teaching only. Participants were evaluated on psychological measures (intrinsic motivation inventory) and dexterity measures (Purdue Pegboard Test, Grooved Pegboard Test, and a grip-lift task). **Findings:** The only significant group difference over time was displayed by the control group on preload duration of the non-dominant hand for the grip-lift task. But it should be noted that the groups differed significantly at baseline testing, with the control group performing significantly poorer, and therefore having the better improvement rate since the improvement is related to the amount to improve. The authors mention several factors leading to no differences between the groups. First, the low number of participants (n=44), second the short additional training period for the two experimental groups (two weeks), which might not have been long enough to show training effects. The authors also mention the study by Bitter et al. (2011) and say that the significant effects of that study might be due to immediate testing, which does not evaluate lasting change. Overall, this study showed no significant improvements of additional sensory and motor training, which took place over the course of two weeks, compared to standard scalpel teaching practice. **Risk of bias:** Low ●

5.3 Breathing

Three studies were conducted to evaluate the effects of Awareness Through Movement lessons on breathing abilities.

Ramli and Roslina (2012) conducted a randomised controlled trial to compare group lessons of the Feldenkrais Method to improve rehabilitation in patients with chronic obstructive pulmonary disease (COPD) with a standard pulmonary rehabilitation program. Thirty-six patients with a mean age of 65.7 years participated in the study and both the experimental Feldenkrais Method group and the control group took part in interventions twice per week for eight weeks. Outcome measurements included Forced Expiratory Volume in one second (FEV1), the Borg score and the 6-Minute Walk Test (6MWT). The Borg score allows patients to grade the intensity of their breathlessness, while the 6MWT measures how far patients can walk in 6 minutes. **Findings:** Neither the experimental, nor the control group showed significant improvement in FEV1. For the Borg score, there was a significant improvement in the standard protocol control group only, but both groups improved significantly in the 6MWT as a within-group effect. There was no significant difference detected between the two groups for the 6MWT. Since the standard pulmonary rehabilitation program involves high intensity exercise and increased cardiovascular

endurance, the authors suggest the change in the Borg score for the control group is a consequence of desensitization. The improved distance in the 6MWT in the Feldenkrais Method group is consistent with a true physiological training effect and the various movement patterns in the Feldenkrais Method classes which may have improved respiratory muscle function and gas exchange. The authors conclude that both interventions demonstrated relevance to COPD patients. While some patients might better tolerate the Feldenkrais Method lessons, it does not provide better outcomes than the standard protocol. **Risk of bias:** Low ●

Another observational pilot study was done by **Ramli et al. (2013)** to study the Feldenkrais Method as an alternative therapy for patients with chronic obstructive pulmonary disease (COPD). Eleven participants, aged between 53 and 73 years participated in the study, all of whom were diagnosed with a severe COPD. Patients received one Feldenkrais Method Awareness Through Movement lesson per week over the course of eight weeks. The content of the lessons varied from week to week and included topics of awareness, relaxation, breathing, and trunk mobility. Outcome measurements before and after the intervention included the 6-minute Walking Test, lung function tested through spirometry and quality of life. **Findings:** Results showed a significant improvement in the 6-minute Walk Test and Forced Expiratory Volume, both with large effect sizes. Quality of life measures did not change significantly throughout the course of the intervention. The authors addressed several limitations, such as a small sample size and the lack of a control group with randomized allocation. The results of this pilot study were promising but need to be confirmed by future studies with a larger sample, control group and random allocation of patients with COPD. **Risk of bias:** Critical ●

A well-designed randomised controlled trial by **Mohan et al. (2021)** evaluated the effects of Feldenkrais Method Awareness Through Movement lessons to improve respiratory characteristics in patients with non-specific lower back pain (NS-LBP). Forty participants were randomly assigned to the experimental and control group. Whilst the control group received a standard physiotherapy intervention three times per week, the experimental group received Feldenkrais Method Awareness Through Movement lessons combined with the routine physiotherapy protocol. The authors conducted a sample size calculation and assessors remained blinded to the treatment conditions. Outcome measures included respiratory muscle strength, respiratory muscle endurance, assessment of breathing patterns, pain perception, chest expansion, and core stability. **Findings:** Results showed significant improvements in expiratory and inspiratory muscle strength for the experimental group, but not for the control group. Respiratory muscle endurance only improved significantly in the control group. Additionally, there was a significant reduction in pain and a significant improvement in chest expansion in the experimental group alone. Also, lumbo-pelvic stability improved in the experimental group alone. Breathing patterns showed a non-significant improvement in the experimental group. The authors conclude that the Feldenkrais Method is a potential additional form of exercising, which could improve respiratory function, pain and lumbo-pelvic stability components in populations with lower back pain. **Risk of bias:** Very low ●

5.4 Posture

Two papers studied the effect of Feldenkrais Method interventions on posture. In these two studies the effect on skeletal alignment in standing was evaluated.

Quintero et al. (2009) studied the effect of ten once per week Feldenkrais Awareness Through Movement sessions on head posture in bruxist children. The study design was a randomised controlled trial and included 26 children between 3-6 years of age. There was no intervention in the control group. **Findings:** Results showed significant improvements in head posture after the intervention compared to the control group with a clinically meaningful change in the craniovertebral angle (CVA). **Risk of bias:** Very Low ●

Gil (2018) conducted a study to assess the effects of a Feldenkrais Method program and a so-called “Motion and Posture” (MAP) program on posture and quality of life. The Motion and Posture program is derived from the Feldenkrais Method but combines it with more conventional stability exercises. The study design was a non-randomized controlled trial, and 243 participants took part in either 14 Feldenkrais Method or MAP lessons. **Findings:** Quality of life improved in both groups and lordosis gap decreased in both groups as well. Whilst the decrease of the lordosis gap was bigger in the Motion and Posture group, kyphosis only improved in the Feldenkrais Method group. The authors conclude that quality of life and posture can be improved by both programs. Unfortunately, the paper did not provide clear information about whether the improvements were statistically significant from pre- to post-intervention. **Risk of bias:** Critical ●

5.5 Muscle Tone

One randomized controlled trial by **Brummer et al. (2018)** studied the effect of Feldenkrais Method Functional Integration on muscle tone in the supine position. Thirty volunteers received one individual Functional Integration session, in randomized order either first on the right or on the left side of the body. Evaluation consisted of pressure points and contact surface, documented with the Xsensor-Measurement-System as well as of subjective sensations. **Findings:** Results showed that pressure increases differentially on the side that is treated first and overall pressure and contact surface increased significantly after the treatment. The authors reported large effect sizes and observed power for all effects close to 1, meaning that a replication of the study would not need a much larger sample size. In conclusion their results demonstrated that the treatment sessions with the Feldenkrais Method changed muscle tone, leading to a more relaxed supine position with respect to pressure and contact surface on the mat. **Risk of bias:** Very low ●

5.6 General Health Assessment

Even though this literature review is focusing on motor functioning, the author included the results of the evaluated studies described above, which also assessed the effect of Feldenkrais

Method sessions on a general sense of subjective wellbeing, most often evaluated by questionnaires on quality of life.

In the study by Gutman et al. (1977), whilst not yielding significant statistical differences between groups, participants in the Feldenkrais Method group worried less about their health after the intervention. Also, 26.3 % reported that they had more energy after the course, compared to before. In addition, more participants (32 %) in the Feldenkrais Method group than in the control groups (11-21%) reported that they slept better after the program. In the study by Hall et al. (1994), participants in the Feldenkrais Method group significantly increased their vitality and physical functioning, as measured by the SF-36 Quality of Life (QoL) questionnaire. The multiple case study by Stephens et al. (1999) reported a generally increased sense of wellbeing and the study by Stephens et al. (2005) reported an improvement of the SF-36 vitality and mental health subscale scores in the experimental group, indicating an increased sense of wellbeing after participating in Awareness Through Movement classes. However, the observational pilot-study by Ramli et al. (2013) did not show any significant changes in Quality of Life between the baseline and post-intervention period. Cook et al. (2014) mentions improvements in Quality of Life after the Feldenkrais Method intervention for women between 40 and 80 years of age. The randomized controlled trial by Nambi et al. (2014) showed significant improvements in QoL in an ambulatory geriatric population.

As seen by these results, the Feldenkrais Method seems to have beneficial effects on subjective wellbeing, perceived stress, as well as mental health, and a general sense of health.

6. Discussion

First, it must be noted, that the studies described in this review on the Feldenkrais Method and motor functioning are very heterogeneous in terms of their study characteristics, risk of bias, and area of investigation. While most studies found a significant positive effect, some studies did not. Focusing on the studies with a “very low” or “low” risk of bias, some patterns can be detected, and the different results can lead to an overall picture.

In the area of **mobility and balance**, several studies report an improvement in perceived exertion of movement tasks (Brown and Kegerreis 1991; Chinn et al. 1994; Ruth and Kegerreis 1992) and an EMG measurement during a flexion task showed reduced muscle activity after the intervention (Brown and Kegerreis 1991), suggesting that the Feldenkrais Method can improve movement efficiency. Several studies report an improvement in functional movement patterns, such as reaching (Bipinbhai 2013; Dunn and Rogers 2000; Hillier et al. 2010; Hopper et al. 1999; Nambi et al. 2014). The best studied effect is the improvement of balance and mobility in the aging population (Bipinbhai 2013; Hillier et al. 2010; Nambi et al. 2014; Ullmann et al. 2010; Vrantsidis et al. 2009). Interesting are the different results of two studies investigating the change of hamstring flexibility, measured in an active-knee-extension test. While James et al. (1998) found no significant effect after four Awareness Through Movement sessions within two weeks, Stephens et al. (2006) found significant improvements after 8-15 sessions over the

course of three weeks. A possible explanation for this difference might be the length and intensity of the study or the lessons used as intervention to target active hamstring muscle flexibility.

In studies with symptomatic individuals having a neurological condition, the Functional Integration study by Johnson et al. (1999) showed no improvements in hand dexterity or multiple sclerosis (MS) performance scales, but significant reductions in anxiety levels and perceived stress. On the other hand, the Awareness through Movement study by Stephens et al. (2001) showed significant improvements on balance and balance confidence in individuals with multiple sclerosis. The study by Teixeira-Machado et al. (2017) found significant improvements on a variety of functional outcome measures for individuals with Parkinson's disease. Serrada et al. (2022) found clinically meaningful effects of Awareness through Movement classes for stroke recovery, tested by leg and arm motor-impairment scales, body awareness, and quality of life.

For the **dexterity of the hand**, one study by Bitter et al. (2011) found significant improvements after one two-hour Feldenkrais Awareness Through Movement session compared to a sham intervention of progressive muscle relaxation. In another study, when compared to a standard protocol for hand dexterity teaching for learning scalpel skills over two weeks, additional Awareness Through Movement sessions were not beneficial (Causby et al. 2016). Several questions arise from these findings: Are the effects in the study by Bitter et al. (2011) lasting effects, or were the positive results a consequence of immediate testing? Would the results of the study by Causby et al. (2016) differ if it would take place over a longer period and with more consistent baseline characteristics between the groups?

Two good studies on **breathing** both found significant improvements in respiratory muscle function (Mohan et al. 2021; Ramli and Roslina 2012). Also, the study on head posture in bruxist children found clinically meaningful improvements (Quintero et al. 2009).

Interestingly, the Functional Integration study by Brummer et al. (2018), showing a significant lowering of **muscle tone** in the supine position, corresponds with the effect of the Functional Integration study by Johnson et al. (1999) who reported decreased levels of anxiety and stress. It is a well-established psychophysiological fact, that high levels of stress and anxiety are directly linked to a higher overall muscle tone in the body (Hazlett et al. 1994; Plüss et al. 2009; Sainsbury and Gibson 1954).

The several positive effects of Awareness Through Movement and Functional Integration lessons on quality of life further suggest a positive effect on self-perception, body awareness, and overall sense of wellbeing and vitality.

In comparison to standard treatment protocols and general exercises, the results are mixed. The study by Hillier et al. (2010) showed small advantages of Awareness Through Movement sessions in improving balance, compared to a generic balance class. Chinn et al. (1994) found

an improvement in perceived exertion following Awareness Through Movement sessions compared to general upper body exercises. Ramli and Roslina (2012) did not find the Feldenkrais Method classes to be superior to a standard treatment approach for COPD patients. Bipinbhai (2013) found the Feldenkrais Method classes to be better in improving balance in older adults than a general balance class. While Causby et al. (2016) did not find the Feldenkrais Method to be an improvement compared to a standard scalpel training in students, the study by Henry et al. (2020) found the Feldenkrais Method being used in addition to physiotherapy being more effective than physiotherapy alone in treating breathing problems for people with non-specific lower back pain.

No studies reported risks or adverse effects, making the Feldenkrais Method a very safe form of intervention. This is in line with findings from other authors (Ernst 2022).

When looking at the number of sessions needed to see an effect, some studies reported significant improvements after only one session, while other studies showed an effect after eight or more sessions over the course of several weeks. It remains unclear whether and how long these effects last. The number of sessions needed to see an effect seems to depend on what the goal of the intervention is and no suggestions for the amount and intensities can be given based on the current findings.

6.1 Lack of Studies including Functional Integration

The reasons for having few studies including the manual modality of Functional Integration are assumed to be manifold. One reason is that sessions in Functional Integration do not follow a fixed protocol and there is great inter- and intra-individual variability between Functional Integration sessions, even for the same conditions. This is due to the reason that the Feldenkrais Method conceptualizes human organisms and their neuromuscular system as a dynamic, complex, and adaptive system and therefore interventions in Functional Integration follow an exploratory process, using so called meta-principles along specific technical aspects of manipulation (Buchanan 2012; Russell 2020). This inter- and intra-individual variability poses challenges to the replicability of Functional Integration studies. Further, it is difficult to adequately control for confounding practitioner-client interaction effects, which are known to be substantial in hands-on body-mind practices (Mehling et al. 2005). Nevertheless, as Mehling et al. (2005) suggest, several ways exist to minimize bias in studies of hands-on bodywork for challenges regarding blinding, control group and bias in recruitment and attrition. Another reason for the lack of studies including Functional Integration is the cost factor, as having multiple individual sessions is more resource intensive than giving group sessions.

The author further suggests conceptualizing hands-on studies in Functional Integration with a ‘Black-Box’ Model, where the specific manipulations are of less importance. Since every Functional Integration session uses the same set of basic principles, the likelihood and therefore

the replicability of different sessions is still given. Also, combining quantitative with qualitative outcome measures might better grasp the reality of the effects of Functional Integration.

6.2 Possible Mechanisms of Action

Thinking and theorizing about the mechanism of action by which the Feldenkrais Method improves motor functioning has been taken up by many authors in the past. Focusing on the group modality Awareness Through Movement, there is a common understanding that the Feldenkrais Method improves, changes and provides new functional whole-body movement patterns (Bate 1994; Bisges and Newton 1992; Dunn and Rogers 2000; Hopper et al. 1999; James et al. 1998; Rywerant 1983; Serrada et al. 2022). Stephens and Hillier (2020) provide a section on the mechanism of action in their recent review, concluding that the Feldenkrais Method changes the pattern of movement coordination as a result of a process of sensorimotor learning. An in-depth analysis of the elements of motor learning and postural control was done by Connors et al. (2011), which found that motor learning and postural control theory provides a sound theoretical basis for the effectiveness of the Feldenkrais Method in improving balance. Bate (1994) provided a similar approach in explaining some effects of the Feldenkrais Method with motor control theories, while Stephens et al. (2001) state that Awareness Through Movement sessions incorporate basic principles of balance training. An outline of several principles related to the efficient use of the neuromuscular system can also be found in the article of Lyttle (1997). Additionally, several authors point out the exploratory learning nature of the Feldenkrais Method (Russell 2020; Wildman 1986). This is also the topic of the theoretical article by Lafe and Pacheco (2019), which elaborates the connection between the Feldenkrais Method and the search strategy approach to skill acquisition based on dynamical systems theory. Also, the importance of awareness and attention is stressed by several authors (Clark et al. 2015; Mattes 2016; Wildman 1986). Wildman (1986) described the Feldenkrais Method as a process to develop attention and to improve the ability to make sensory distinctions that are connected to improving motor ability.

6.3 Recommendations for Future Research

Designing and planning research programs to study the Feldenkrais Method is a difficult and complex undertaking. When looking at the current literature, the author recommends the following for future studies.

1) Focusing on randomized controlled studies with a sample-size calculation, especially in studies with symptomatic individuals where the aim is to investigate the clinical effect of functional outcomes for these clinical populations.
2) Studies with control groups either receiving a well-designed sham intervention or a standard treatment approach.
3) More studies on the effects of Functional Integration, especially with children with cerebral palsy or people in neurorehabilitation in general. This is a frequently recommended and utilized application of Functional Integration sessions

(Shelhav-Silberbush 1988; Panova et al. 2017). Currently a five-year long study with 20 children with cerebral palsy is being conducted at the University Hospital in Padova, Italy. This is the first long-term study of this kind (Chioggia Redazione Web 2023).

4) More studies with different age groups as sample population.
5) Design studies to assess the effects of Feldenkrais Method interventions on joint mobility and basic coordination of voluntary movement like right-left, up-down, back-front, hand-eye and eye-foot coordination in comparison to assessing more complex, context-dependent motor actions, such as walking, running, jumping, climbing, crawling, swimming, throwing, reaching for something and changing of elementary body position. The international classification on function, disability, and health (ICF) by the WHO could serve as a possible framework (Stucki 2005).
6) Use repeated measurements designs to compare the effect of different amounts of sessions and intensities.
7) Include follow-up assessments to assess the retention of intervention effects.

7. Conclusion

In many areas of study and for many aspects of motor functioning, studying the various possibilities and potential of the Feldenkrais Method has been limited. Nevertheless, this scoping review of research studies and scholarly literature about the Feldenkrais Method and motor functioning gives evidence and makes it seem plausible that the Feldenkrais Method works through principles of motor control and motor learning to improve functions mediated through the neuromuscular system. Functions such as balance, mobility, intra- and inter-muscular coordination, whole-body coordination, breathing, posture, and muscle tone can be improved by the Feldenkrais Method. Further research is needed to specify the effects and the amount of practice needed for the retention of newly found functional movement patterns in the variety of the population who can benefit from the Feldenkrais Method.

Acknowledgements

The author thanks the Swiss Feldenkrais Association, SFV, for their financial funding, which made this review possible. Also, a big thanks to Cliff Smyth and JoAnne Page, for providing valuable feedback to the first draft of this review and helping in editing this article.

Conflict of Interest

The author was member of the Board of Directors of the Swiss Feldenkrais Association (SFV) while conducting this review. The author claims to have worked according to best practices and in line with scientific procedures and has no personal financial benefit regarding the outcome of this review.

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Biography

Nicola Zollinger completed his studies in Environmental Sciences at ETH Zurich and graduated from his Feldenkrais Training in 2021 in Aurillac, France. He worked as an assistant to a lecturer of mathematical system analysis at his university for three years, where he gained a deeper understanding of complex systems. He also wrote the content for a series of six published videos that explain the Feldenkrais Method to the public and published several articles about the Feldenkrais Method on the website for complementary therapies in Switzerland.

Appendix 1

Table 1, Part 1 - Data Overview

Nr.	Study	Year	ATM/FI	Area	Nr. of Subjects	Age	Sessions	Duration [weeks]	Intensity [Sessions per week]	Healthy Sample
1	Gutman et al.	1977	ATM	Mobility, Balance, General Health Assessment	38	70.9	18	6	3	Yes
2	Brown and Kegerreis	1991	ATM	Mobility	21	28	1	1	1	Yes
3	Ruth & Kegerreis	1992	ATM	Mobility	30	11-36	1	na	na	Yes
4	Hall et al.	1994	ATM	Balance, General Health Assessment	60	71.65	32	16	2	Yes
5	Chinn et al.	1994	ATM	Mobility	23	18-59	1	1	1	No
6	Brown et al.	1996	ATM	Mobility	23	75.92	18	6	3	Yes
7	Stephens et al.	1998	ATM	Mobility	4	38.5	10	10	1	No
8	James	1999	ATM	Mobility	48	23.1	4	2	2	Yes
9	Hopper et al.	1999	ATM	Mobility	75	18.9	1 or 4	2	2	Yes
10	Johnson et al.	1999	FI	Mobility	20	44.8	8	8	1	No
11	Buchanan & Vardaxis	2000	ATM	Balance	20	NA	8	4	2	Yes
12	Dunn & Rogers	2000	ATM	Mobility	12	23	1	1	1	Yes
13	Stephens et al.	2001	ATM	Balance	12	56.2	8	10	1	No
14	Batson & Deutsch	2005	ATM	Mobility, Balance	4	56	15	6	na	No
15	Stephens et al.	2005	ATM	Mobility, General Health Assessment	31	79	10	1	10	Yes
16	Stephens et al.	2006	ATM	Mobility	33	25.9	11 on average	3	4 on average	Yes
17	Quintero et al.	2008	ATM	Posture	26	4.7	10	10	1	No
18	Vrantsidis et al.	2009	ATM	Balance	55	75.4	16	8	2	Yes
19	Manuél Heister	2010	ATM	Balance	30	NA	8	4	2	No
20	Hillier et al.	2010	ATM	Balance, General Health Assessment	22	NA	8	8	1	Yes
21	Ullmann et al.	2010	ATM	Mobility, Balance	47	75.6	15	5	3	Yes
22	Connors et al.	2011	ATM	Mobility, Balance	63	75 (MD)	20	10	2	Yes
23	Bitter et al.	2011	ATM	Dexterity	29	23	1	1	1	Yes
24	Khurana et al.	2012	ATM	Mobility	25	21-26	15	2	7	Yes
25	Ramli & Roslina.	2012	ATM	Breathing	36	65.7	16	8	2	No
26	Bellafiore et al.	2012	ATM	Mobility	17	34	8	4	2	No

27	Ramli et al.	2013	ATM	Breathing	11	63.8	8	8	1	No
28	Bipinbhai	2013	ATM	Balance	45	71.36	20	4	5	Yes
29	Webb et al.	2013	ATM	Mobility, General Health Assessment	15	67	60	30	2	No
30	Cook et al.	2014	ATM	Mobility, Balance, General Health Assessment	46	60	5-10	1	5-10	Yes
31	Nambi et al.	2014	ATM	Balance, General Health Assessment	60	70	18	6	3	Yes
32	Causby et al.	2016	ATM	Dexterity	44	23	7	2	3-4	Yes
33	Maddali-Bongi et al.	2017	ATM	Mobility	10	55.3	10 + daily home exercises	5	2	No
34	Palmer	2017	ATM	Balance	87	76 (MD)	12	6 or 12	1 or 2	Yes
35	Torres-Unda et al.	2017	ATM	Mobility, Balance	32	48.94	30	30	1	No
36	Teixeira-Machado et al.	2017	ATM	Mobility, Balance	30	61	50	25	2	No
37	Gil	2018	ATM	Posture	243	24	14	14	1	Yes
38	Brummer et al.	2018	FI	Muscle Tone	30	37.9	1	1	1	Yes
39	Mohan et al.	2021	ATM	Breathing	34	18-55	24	8	3	No
40	Kang et al.	2021	ATM	Mobility	9	69.1	24	24	1	No
41	Serrada et al.	2022	ATM	Mobility	20	68.4	20	10	2	No

Table 1, Part 2

Nr.	Study	OCBM Level of Evidence	Type of control	Blinding	Follow-up	Results sign.	Sample Size Calculation	Pedro Score for RCT	Risk **of** Bias
1	Gutman et al.	3	No Intervention	No Blinding	No	No	No	NA	Serious
2	Brown and Kegerreis	2	ATM without suggestions	No blinding	No	Yes	No	6/11	Low
3	Ruth & Kegerreis	2	No Intervention	No Blinding	No	Yes	No	5/11	Low
4	Hall et al.	2	No Intervention	No Blinding	No	Yes	No	6/11	Low
5	Chinn et al.	2	Sham Intervention (exercise)	No Blinding	No	Yes/No	No	4/11	Low
6	Brown et al.	3	No Intervention	No Blinding	No	Yes	No	NA	Moderate
7	Stephens et al.	4	No control group	No Blinding	No	na	No	NA	Critical
8	James	2	No Intervention/Relaxation	Blinded Assessors	No	No	No	8/11	Very Low
9	Hopper et al.	2	No Intervention	No Blinding	No	Yes	No	6/11	Low

10	Johnson et al.	2	Sham Intervention	Blinded Assessors	No	Yes	No	7/11	Very Low
11	Buchanan & Vardaxis	3	No Information on control Group	No Blinding	No	Yes	No	na	NA
12	Dunn & Rogers	4	No control group/right body side as control / Pseudo-Randomization	No Blinding	No	Yes	No	na	Low
13	Stephens et al.	2	Education (4 Sessions)	No Blinding	No	Yes	No	5/11	Low
14	Batson & Deutsch	4	No control group	No Blinding	No	Yes	No	na	Critical
15	Stephens et al.	3	No Intervention	No Blinding	No	Yes	No	na	Moderate
16	Stephens et al.	2	No Intervention	No Blinding	No	Yes	No	5/11	Low
17	Quintero et al.	2	No Intervention	No Blinding	No	Yes	Yes	7/11	Very Low
18	Vrantsidis et al.	2	No Intervention	Blinded Assessors	No	Yes	Yes	8/11	Very Low
19	Manuél Heister	4	No control group	No Blinding	No	Yes/No	No	na	Critical
20	Hillier et al.	3	Generic Balance Class	Blinded Assessors	No	Yes	No	na	Low
21	Ullmann et al.	2	No Intervention	No Blinding	No	Yes	No	6/11	Low
22	Connors et al.	3	No Intervention	No Blinding	No	Yes	No	na	Moderate
23	Bitter et al.	2	Sham Intervention (PMR)	Double-Blinded	No	Yes	Yes	10/11	Very Low
24	Khurana et al.	4	No control group	No Blinding	No	Yes	No	na	Critical
25	Ramli & Roslina.	2	Pulmonary Rehabilitation Program	No Blinding	No	No	No	5/11	low
26	Bellafiore et al.	2	No Intervention	No Blinding	No	No	No	6/11	low
27	Ramli et al.	4	No control group	No Blinding	No	Yes	No	NA	Critical
28	Bipinbhai	2	Alexander and Balance Class	No Blinding	No	Yes	No	7/11	Very Low
29	Webb et al.	4	No control group	No Blinding	No	Yes	No	na	Critical
30	Cook et al.	3	No Intervention	No Blinding	No	Yes	No	NA	Serious
31	Nambi et al.	2	Pilates and Walking exercises	No Blinding	No	Yes	No	7/11	Very low
32	Causby et al.	2	Motor practice, usual teaching	Blinded Assessors	Yes	No	Yes	5/11	low
33	Maddali-Bongi et al.	4	No control group	No Blinding	No	na	No	na	Critical
34	Palmer	3	Waitlist	Blinded Assessors	No	Yes/No	No	na	Moderate
35	Torres-Unda et al.	2	No Intervention	No Blinding	No	Yes	No	6/11	low

36	Teixeira-Machadeo et al.	2	Educational Lecture	No Blinding	No	Yes	No	7/11	Very low
37	Gil	4	No control group	No Blinding	No	Yes	No	na	Critical
38	Brummer et al.	2	Crossover Design	No Blinding	No	Yes	No	7/11	Very low
39	Mohan et al. 2021	2	Physiotherapy	Blinded Assessors	No	Yes	Yes	9/11	Very low
40	Kang et al.	4	No control group	No Blinding	Yes	Yes/No	No	na	Critical
41	Serrada et al.	2	Home-based ATM Audios	Blinded Assessors	No	Yes	Yes	6/11	low

Appendix 2

Table 2 - Outcome Measurements

Outcome Measurement	**Publication**
Philadelphia Geriatric Centre Morale Scale	Gutman et al. 1977
VIRO scale (a scale for assessing interview behavior of elderly people)	Gutman et al. 1977
Height, Weight, heart rate, blood pressure	Gutman et al. 1977
Range of Motion - Rotation Flexibility	Gutman et al. 1977
Balance rail test	Gutman et al. 1977
Dermatome scoring system for pain and stiffness	Gutman et al. 1977
Borg Scale perceived exertion, Visual Analog Scale of perceived exertion (VAS)	Brown & Kegerreis 1991, Ruth & Kegerreis 1992, Chinn et al 1994, Hopper et al. 1999, Ramli & Roslina 2012
EMG activity	Brown & Kegerreis 1991
Range of motion with cervical goniometer	Ruth & Kegerreis 1992
Functional Arm reach test (supine, along wall)	Chinn et al. 1994

Functional Reach Test (Standing, forward reach)	Brown et al. 1996, Hillier et al. 2010, Bipinbhai 2013, Nambi et al. 2014, Palmer 2017, Teixeira-Machado et al. 2017
Modified Functional Reach Test (in Sitting)	Brown et al. 1996, Bipinbhai 2013
SF 36 QoL, AQoL, RAND -36, SrS-22	Hall et al. 1994, Stephens et al. 2005, Vrantsidis et al. 2009, Hillier et al. 2010, Ramli et al. 2013, Webb et al. 2013, Nambi et al. 2014, Gil 2018
FAI daily living index	Hall et al. 1994, Vrantsidis et al. 2009
Falls Efficacy Scale	Hall et al. 1994, Vrantsidis et al. 2009, Ullmann et al. 2010
Timed up and Go Test (TUG)	Hall et al. 1994, Brown et al. 1996, Vrantsidis et al. 2009, Hillier et al. 2010, Ullmann et al. 2010, Bipinbhai 2013, Nambi et al. 2014, Palmer 2017 Teixeira-Machado et al. 2017
Berg Balance Test	Hall et al. 1994, Batson & Deutsch 2005, Bipinbhai 2013, Teixeira-Machado et al. 2017
Physical Activity Scale (PASE)	Hall et al. 1994
Pro Balance Master Test	Hall et al. 1994
Dartmouth COOP	Brown et al. 1996
Range of Motion – Active Knee Extension Test	James et al. 1998, Hopper et al. 1999, Stephens et al. 2006
Fatigue Severity Scale (FSS)	Stephens et al. 1998
Index of Wellbeing (IWB)	Stephens et al. 1998

PEAK Motus 2D Motion Analysis of gait and supine to stand	Stephens et al. 1998, Stephens et al. 2005
Sit and reach measurement	Hopper et al. 1999, Dunn & Rogers 2000, Bellafiore et al. 2012
Pegboard test for hand dexterity	Johnson et al. 1999, Bitter et al. 2011, Causby et al. 2016
Hospital Anxiety and Depression Scale (HAD)	Johnson et al. 1999
MS-Self Efficacy Scale	Johnson et al. 1999, Stephens et al. 2001
Perceived Stress Scale (PSS)	Johnson et al. 1999
Performance Quality of Life	Johnson et al. 1999
AMTI Force Plate for 7 standing tasks	Buchanan & Vardaxis 2000, Webb et al. 2013
Prospective Falls Record	Stephens et al. 2001
EQUISCALE Functional Balance	Stephens et al. 2001
mCTSIB Balance Protocol	Stephens et al. 2001, Vrantsidis et al. 2009
ABC Balance Confidence Scale	Stephens et al. 2001, Ullmann et al. 2010, Connors et al. 2011
Dynamic Gait Index (DGI)	Batson & Deutsch 2005
Stroke Impact Scale (SIS)	Batson & Deutsch 2005, Serrada et al. 2022
Lateral Cephalogram	Quintero et al. 2009
Human Activity Profile (HAP)	Vrantsidis et al. 2009, Webb et al. 2013
Abbreviated Mental Score	Vrantsidis et al. 2009
Four Square Step Test	Vrantsidis et al. 2009, Connors et al. 2011, Webb et al. 2013
Step Test	Vrantsidis et al. 2009

Clinical Stride Analyzer (CSA)	Vrantsidis et al. 2009
Timed Sit to Stand	Vrantsidis et al. 2009, Teixeira-Machado et al. 2017
Single Leg Stance time (SLS)	Hillier et al. 2010
Walk on Floor Eyes closed (WOFEC)	Hillier et al. 2010
Self-Selected Gait Speed	Ullmann et al. 2010, Connors et al. 2011
Grip Lift Test	Bitter et al. 2011, Causby et al. 2016
Trunk Lift Test	Bellafiore et al. 2012
6 min Walk Test (6MWT)	Ramli & Roslina 2012, Ramli et al. 2013, Webb et al. 2013
Forced Expiratory Volume	Ramli & Roslina 2012, Ramli et al. 2013
Stair Climbing Test	Webb et al. 2013
Western Ontario McMaster Universities Osteoarthritis Scale	Webb et al. 2013
Tekscan Pressure Mat	Cook et al. 2014
Intrinsic Motivation Inventory (IMI)	Causby et al. 2016
Trail Making Test A & B	Ullmann et al. 2010
VAS for Pain	Maddali-Bongi et al. 2017
VAS for Fatigue	Maddali-Bongi et al. 2017
BAS-G	Maddali-Bongi et al. 2017
BASDAI	Maddali-Bongi et al. 2017
MASES	Maddali-Bongi et al. 2017
Schöber Test	Maddali-Bongi et al. 2017
Finger Floor Distance (FFD)	Maddali-Bongi et al. 2017
Tandem Stance	Palmer 2017

OPTIMAL Self Report	Palmer 2017
Short Physical Performance Battery (SPPB)	Torres-Unda et al. 2017
Stabilometric Platform	Torres-Unda et al. 2017
XSensor Pressure Mapping System	Brummer et al. 2018
Lesson Effect Questionnaire	Gil 2018
Digital Inclinometer	Gil 2018
Maximal Inspiratory Pressure (MIP)	Mohan et al. 2021
Maximal Expiratory Pressure (MEP)	Mohan et al. 2021
Maximum Voluntary Ventilation (MVV)	Mohan et al. 2021
Total Faulty Breathing Scale (TFBS)	Mohan et al. 2021
Cloth Tape Measure for Chest Expansion	Mohan et al. 2021
Pressure Biofeedback Device (PBU) for Core Stability	Mohan et al. 2021
Unified Parkinson's disease rating scale (UPDRS)	Kang et al. 2021
Gait Analysis	Kang et al. 2021
Non.motor Symptoms Scale (NMSS)	Kang et al. 2021
Parkinson Disease Questionnaire (PDQ-39)	Kang et al. 2021
Asberg Depression Rating Scale	Kang et al. 2021
Tinetti Scale	Kang et al. 2021
Hoehn and Yahr Stage	Kang et al. 2021
Erasmus Nottingham Sensory Assessment	Serrada et al. 2022
MAIA (Multidimensional Assessment of Interoceptive Awareness)	Serrada et al. 2022
Fugl-Meyer Upper and Lower Extremity	Serrada et al. 2022

Ten metre walk test (10MWT)	Serrada et al. 2022
Patient specific functional scale (PSFS)	Serrada et al. 2022
Figure-of-eight walk test	Teixeira-Machado et al. 2017
Rollover Task	Teixeira-Machado et al. 2017
360-Degree turn-in-place task	Teixeira-Machado et al. 2017
Hip-flexion strength test	Teixeira-Machado et al. 2017