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METHODOLOGICAL VARIETY IN SENSORY-MOTOR INTERVENTIONS FOR REDUCING THE RISK OF FALLS IN THE ELDERLY: A SYSTEMATIC REVIEW

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RESUMO

Objetivos: Analisar a diversidade de exercícios sensório-motores relacionados à metodologia e resultados para redução do risco de queda em idosos, bem como ajudar a orientar novos estudos relacionados ao tema diante do que já está sendo feito. Métodos: As pesquisas foram realizadas em três bases de dados: PubMed, Scielo e PEDro, utilizando os seguintes descritores: população idosa, risco de quedas, propriocepção e exercícios sensório-motores. Os critérios de inclusão foram considerados estudos randomizados publicados a partir de 2012 nos idiomas: inglês e português associados a grupos de intervenção. Nos critérios de exclusão foram excluídos estudos com patologias pré-determinadas que não possuíam o texto completo gratuito na Internet. Resultados: Nos 15 artigos selecionados, 40% dos estudos avaliaram dados entre 30 e 50 participantes; 27% optaram por um período de intervenção entre 12-14 semanas e apenas 1 estudo realizou acompanhamento. O treinamento proprioceptivo de alta frequência apresentou resultados significativos com $p<0,001$. As intervenções com atividades relacionadas a jogos e Tai Chi expressaram maior satisfação com o tratamento. Conclusão: Apesar de verificar a complexidade numa uniformidade metodológica, pode-se observar a grande importância do treinamento sensório-motor como intervenção, bem como o interesse científico em buscar outras técnicas que potencializem os resultados, a inovação e o desenvolvimento da área.

Palavras-chave: populações idosas; risco das quedas; propriocepção; exercícios sensoriais.

Objectives: To analyze the diversity of sensorimotor exercises related to the methodology and results for reducing the risk of falling in the elderly, as well as to help guide new studies related to the theme in view of what is already being done. **Methods:** Researches were conducted in three databases: PubMed, Scielo and PEDro, using the following descriptors: elderly population, risk of falls, proprioception and sensoriomotor exercises. The inclusion criteria were considered randomized studies published from 2012 on in the languages: English and Portuguese associated with intervention groups. In the exclusion criteria, studies with pre-determined pathologies that did not have the free full text on the Internet were excluded. **Results:** In the 15 selected articles, 40% of the studies evaluated data between 30 and 50 participants; 27% opted for an intervention period between 12-14 weeks and

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only 1 study performed follow-up. High frequency proprioceptive training showed significant results with p <0.001. Interventions with activities related to games and Tai Chi expressed greater satisfaction with the treatment. **Conclusion:** Despite verifying complexity in a methodological uniformity, one can observe the great importance of sensoriomotor training as an intervention, as well as the scientific interest in seeking other Techniques that potentialize the outcomes, innovation and development of the area. **Keywords:** elderly populations; risk of the falls; proprioception; sensory exercises.

1 INTRODUÇÃO

As people get older, they face several physiological transformations that interfere with their socio-behavioral dynamics related to the physical challenges faced. Trials have showed that approximately 30% of individuals over 65 years old have at least one fall frequency once a year and in 50% of them, recurrence of the episode [1]; being the fall the leading cause of injury in adults over 65 years old [2].

The presence of intrinsic and extrinsic factors begins to be determinant in this process, in which the search for quality of life and the reduction of the risks of falls are the main goals for their survival.

Extrinsic factors can be represented by the conditions of the physical place, such as the presence of slippery floors (smooth or wet), rugs, inadequate lighting, stairs, out-of-range switches and the wear of inappropriate shoes [3,4].

The intrinsic characteristics are the individualized characteristics of each patient and their physiological conditions associated with aging (musculoskeletal, cardiac, digestive and urinary disorders, disorders of the nervous, visual, auditory and cognitive systems), as well as use of medicines [5, 6]. Hence the search for knowledge about the most effective behaviors for an intervention with assistance in circumstances that may reduce this risk and obtain more satisfactory outcomes.

Detecting obstacles, sending information to the nervous system, processing them and choosing the best motor response is a skill that the elderly need to constantly develop [7]. The somatosensory system is one of the systems closely linked to the vestibular and visual systems, in which in this triad, they functionally complement each other to act on balance and dynamic stability, relevant in the elderly by constantly fighting against the intrinsic and extrinsic factors that cause falls [8]. Believing that the visual system is one of the most commonly affected with aging due to deterioration in acuity, visual field and night vision related to cataracts, glaucoma and macular degeneration, for example [9]. Researches argue that the proper importance to sensoriomotor exercise may be compensatory for these most affected mechanisms, but there is still uncertainty as to what type of exercise to reduce risk of the fall [10,11].

Considering the difficulty in dissociating such systems and obtaining clarity in scientific studies that focus on sensorimotor exercises, the objective of this systematic review is, therefore, to plan the methodologies related to sensorimotor training as well as the results obtained by them.

METHODS

This systematic review was based on the “The PRISMA Statement” guidelines [12]. For this study there was no previous registration or financial investment to perform it. The following keywords were used: elderly populations, risk of the falls, proprioception and sensory exercises in the following data: PubMed, Pedro and Scielo, from August 1, 2019 to September 13, 2019. It was necessary different associations between the descriptors in the databases to select the trials.

Graphics and tables were used to show the variables and simple percentages were calculated to get more information about the trials.

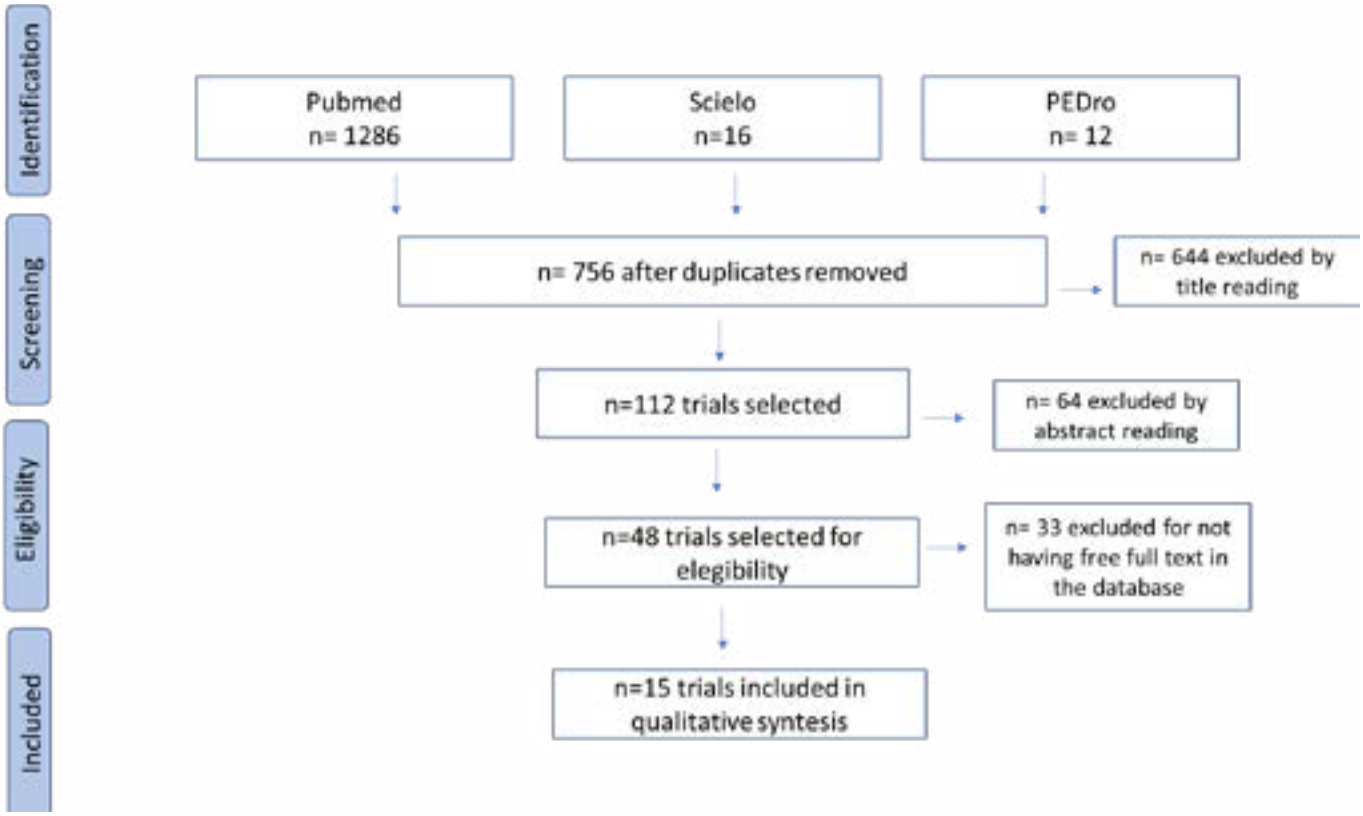
ELIGIBILITY CRITERIA

As Inclusion Criteria was considered the randomized studies published from 2012 in the languages: English and Portuguese associated with intervention groups. Articles that wrote in their titles: association of the theme with predetermined pathologies (neurological, metabolic or orthopedic) or that did not publish the full free text in the internet were excluded from the review.

RESEARCH INFORMATION

A survey to collect articles was performed in 43 days. First, all articles that emerged after the placement of the keywords were detected: 1314 articles. After that, it was selected 756 trials per publication's year. A second screening was performed after reading the title (titles associated with pathologies were excluded), in which 112 articles were pre-selected. Finally, after reading the abstract (in which 64 articles were excluded for not having a control group and intervention group determined), 48 studies were captured.

After reading the entire text, they were properly selected to those specific to sensoriomotor system with all free content on the internet, with 33 exclusions and 15 definitive inclusions in the review. Two reviewers performed the screening process in which the selections were performed and later discussed by both. Disagreements were solved consensually after dialogue and approach to facts.



FLOWCHART BASED ON THE PRISMA STATEMENT MODEL

The evidences will be displayed in narrative format with visual representation in table and design graphic.

RESULTS

Given the analyzed studies, it can be observed a wide variety of the number of sampling described among the 15 articles. 6.66% had a smaller sample than 10 participants; 40% of the studies evaluated data between 30 and 50 participants, 33.3% conducted their research between 60 and 80 individuals. Sampling number above 100 is represented by 20% of selected studies. Regarding age, it has been considered elderly, individuals aged 60 years old and over. Look at the table 1.

Table1. Relationship between sample number and age range among the articles selected for the current systematic review.

AUTHOR; YEAR	SAMPLING NUMBER (N)	AGE
Riva *et al.*; 2019 [13]	61	65-85
Gschwind YJ; 2015 [14]	148	65 +
Holt *et al.*; 2016 [18]	60	65 +
Light *et al.*; 2016 [26]	76	64-88
Katrancha *et al.*; 2015 [19]	32	60 +
Schoene *et al.*; 2013 [15]	37	65 +
Vogler *et al.*; 2012 [27]	180	65 +
Kim et al.; 2014 [25]	30	65 +
Liu *et al.*; 2012 [20]	60	60-85
Sadeghi *et al.*; 2017[16]	32	65
Zheng *et al.*; 2013 [21]	100	60-85
Treml *et al.*; 2013 [17]	32	60-80
Carvalho *et al.*; 2015 [23]	40	60 +
Cabreira *et al.*; 2014 [24]	62	63-73
Nascimento *et al.*; 2012[22]	9	67-78

The PEDro Scale was used as a tool to measure the methodological quality of selected scientific articles, as well as bias control. The scores were collected from the PEDro Database (0-11) where 66.66% of the selected articles were indexed in this systematic review: 1 article with score 2; 3 articles with score 4; 1 article with score 6; 3 articles with score7 and 2 articles with score 8. 5 articles weren't detected in the PEDro database, but they were included in this study because these data, individually, weren't the most important topic and 3 of them by Brazilian authors. See table 2.

AUTHOR; YEAR	SCORE 1	SCORE 2	SCORE 3	SCORE 4	SCORE 5	SCORE 6	SCORE 7	SCORE 8	SCORE 9	SCORE 10	SCORE 11
Riva *et al.*; 2019 [13]				X							
Gschwind YJ; 2015 [14]*	-	-	-	-	-	-	-	-	-	-	-
Holt *et al.*; 2016 [18]							X				
Light *et al.*; 2016 [26]		X									
Katrancha *et al.*; 2015 [19]							X				
Schoene *et al.*; 2013 [15]							X				

Continuando Tabela 2

Vogler *et al.*; 2012 [27]								X			
Kim *et al.*; 2014 [34]				X							
Liu *et al.*; 2012 [20]				X							
Sadeghi *et al.*; 2017[16]						X					
Zheng *et al.*; 2013 [21]								X			
Treml *et al.*; 2013 [17]*	-	-	-	-	-	-	-	-	-	-	-
Carvalho *et al.*; 2015 [23]*	-	-	-	-	-	-	-	-	-	-	-
Cabreira *et al.*; 2014 [24]*	-	-	-	-	-	-	-	-	-	-	-
Nascimento *et al.*; 2012[22]*	-	-	-	-	-	-	-	-	-	-	-

Table 2. Trials' scores by PEDro Scale (0-11) indexed in PEDro Database.
Note: * These studies were not indexed in the PEDro Database.

Regarding the number of weeks in which physiotherapy intervention took place, four studies were observed that maintained a period between 12-14 weeks and 4-6 weeks, followed by 3 studies that used 8-10 weeks of intervention, 2 studies with methodology longer than 14 weeks (16 weeks) and less than 4 weeks (1 day). See figure 1.

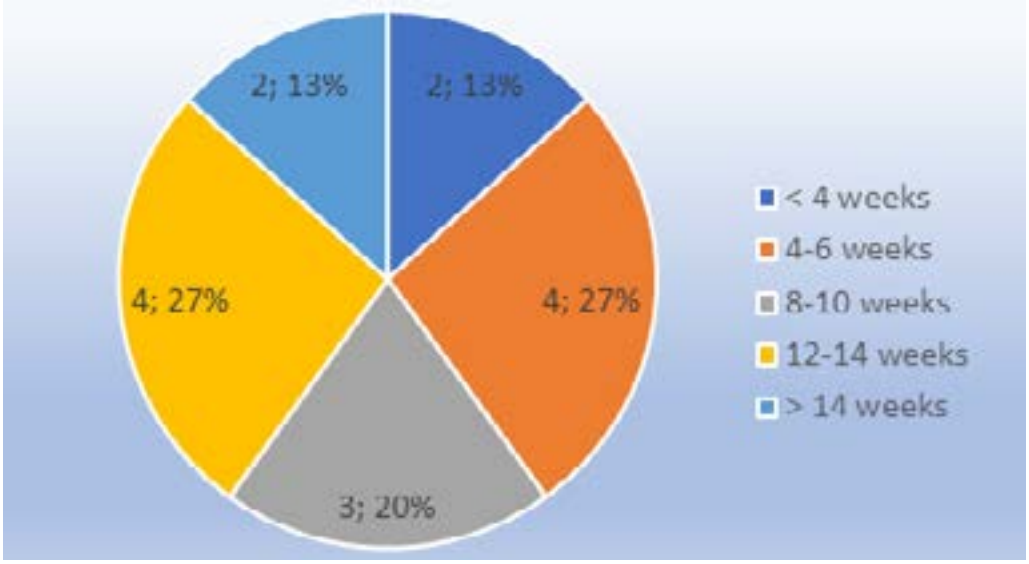


Fig. 1. Proportionality between the amount of RCTs that opted for the same intervention periods.

When referring to sensoriomotor system, the studies presented a great diversity of comparative analyzes between distinct interventions, but interconnected when referring to the search for better outcomes

to reduce the risk of falls in the elderly. In Table 3, the following interventions applied to the Intervention Groups can be analyzed: High Frequency Proprioceptive Training [13], using Exergames Technology [14], [15], [16], [17], association of this intervention with Balance Board Platform [17], Chiropractic Treatment, [18], Tai Chi Method [19], [20], Proprioceptive Protocol Associated with Cognitive Exercise [21] or performed alone [22], Infrapatellar Bandage [23], Kinesio Taping [24], Visual Block [25]. As well as the importance of external stimulation for better treatment adherence [26] and interruption of treatment continuity to observe the loss of acquired results (follow up) [27].

The High Frequency Proprioceptive Training showed significant results with p <0.001 when compared to conventional proprioception exercises. The other trials presented their importance, but without significant alterations. Still in table 3, it is observed that only one article [24] used the placebo effect in their study (Micropore 3M adhesive tape). As well as the follow up of data obtained after a 12 weeks period without intervention, performed by Vogler *et al*., (2012 [27].

The authors Riva *et al*. (2019) [27], Kim *et al*. (2014) [25] and Zheng *et al*. (2013) [21] approach the importance of the visual system as an important element in the proprioception of the elderly population. See table 3.

Studies that conducted activities related to games (exergames) [14], [15], [16], [17] and the Tai Chi technique [19], [20] reported greater expression of satisfaction with treatment. See table 3.

Table3. Comparison between the choice of intervention to be applied in the Intervention Group, its objectives and results achieved.

AUTHOR, YEAR	ASSESSED INTERVENTION	OBJECTIVES	RESULTS
Riva et al.; 2019 [13]	High Frequency Proprioceptive Training (HPT)	Determining increased proprioceptive control and optimization of vision contribution through this tool.	Postural Control p <0.001 Proprioceptive Control p <0.001
Gschwind YJ; 2015 [14]	Use of exergames: SMT, KIN	Unsupervised home exercise programs for proprioceptive improvement and decreased risk of falling.	SMT: improvement in the risk of falling (p = 0.036); proprioception (p = 0.015); reaction time (p = 0.003) KIN: muscle strength (p = 0.032); Risk of falling (p = 0.057); vision (p = 0.010)
Holt et al.; 2016 [18]	Chiropractic Treatment	Analyzing the effectiveness of chiropractic care in improving sensorimotor function associated with the risk of falls.	Improved sense of ankle joint position (p = 0.049) and physical component of quality of life SF-36 (p = 0.04)
Light et al.; 2016 [26]	Phone call	Determining the benefit of telephone contact in patients undergoing home physical therapy and its relationship with factors that influence the decreased risk of falls, such as balance and proprioception.	Due to adherence and psychological incentive to continue treatment, there was a difference in the Berg Scale score between the Intervention Group and Control Group (6.3 and 3.9, respectively).
Katrancha et al.; 2015 [19]	Tai Chi Guided Video	Evaluating the effects of a video-oriented Tai Chi about the center of Balance and the factors that influence the risk of falls.	Benefit suggestion regarding low cost and balance center improvement.

Continuando Tabela 3

Schoene et al.; 2013 [15]	Video game technology	Improving proprioceptive capacity, to decrease the risk of falling through the improvement of physical and neuropsychological factors, to offer autonomy when performing the activity at home.	Increase in adherence and decrease in dropout rate (13.5%)
Vogler et al.; 2012 [27]	Interruption of exercises	Evaluating how much sensorimotor gain and balance was acquired after 12 weeks of intervention and lost after its interruption.	Partial or total loss of the results obtained after 12 weeks of discontinuation of the intervention.
Kim et al.; 2014 [25]	Visual block	Investigating the effects on performing a blindfold exercise program or not.	The Vestibular Stepping Test (VST) and Proprioception Test (PT) changed significantly after the intervention in the Visual Block group.
Liu et al.; 2012 [20]	TAI CHI	Investigating the effects of Tai Chi versus proprioceptive exercise	The results of both were significantly better than the control group, but showed no differences between them.
Sadeghi et al.; 2017[16]	Use of Exergames (Xbox Kinect)	Analyzing the effect of exergames for proprioceptive benefits.	The Knee proprioception increased significantly ($p = 0.001$) in both lower limbs.
Zheng et al.; 2013 [21]	Proprioceptive + cognitive exercises	Evaluating the significance of performing proprioceptive + cognitive exercises to decrease the risk of falls.	Static balance, joint position sense and BBS scores were significantly higher.
Treml et al.; 2013 [17]	Balance Board Platform + Video Game	Evaluating outcomes in conventional proprioceptive protocol versus Balance Board + video game	In the Intervention Group, only the Berg Scale variable showed no significant difference ($p < 0.05$) between pre and post intervention. The virtual reality proposal proved to be more efficient than conventional proprioceptive training.
Carvalho et al.; 2015 [23]	Infrapatellar Bandage	Investigating the effect of adding sensory information on postural control and physical performance in older women with a record of falls and no record at all.	There was a significant difference ($p = 0.001$) in the comparison of TUG with the use of infrapatellar bandage in elderly women with a episode of falls. There was no significant difference in the use of sensory addition in SPPB.
Cabreira et al.; 2014 [24]	Kinesio Taping	Improving proprioception, balance and coordination of the elderly.	There were no applicable changes regarding the Control Group evaluated 48 hours after application.
Nascimento et al.; 2012[22]	Proprioceptive training by itself	Analyzing the effect of proprioceptive training on proprioception, balance and other factors in order to determine the effectiveness of a simple intervention strategy.	Significant improvement in the total score on the Berg scale, decrease in oscillations that represent risk of falls in Romberg, decrease in time to walk a certain distance and, consequently, improvement in static and dynamic balance.

Regarding proprioceptive measurement, a large variability of tools can be found to obtain concise information about the evaluated interventions. Sometimes it has been evaluated in isolation [13], [18], [25], [20], [16], [21] and in other studies, it has been related to participant functionality or a test battery [14] , [26], [19], [15], [27], [17], [23], [24], [22]. See table 4 below.

Three distinct articles evaluated in this study [14], [15], [27] use the Physiological Profile Assessment (PPA) to assess the risk of falls in the elderly who consider among the five applicable sensorimotor tests [28] the usage of the Melbourne Edge Test for visual contrast sensitivity. See table 4.

Table4. Measurement chosen by the authors to verify proprioception in their respective trials.

AUTHOR; YEAR	MEASUREMENT SELECTED FOR PROPRIOCEPTION'S EVALUATION
RIVA *ET AL.*; 2019 [13]	Stability Index
GSCHWIND YJ; 2015 [14]	Physiological Profile Assessment (PPA), Timed Up and Go
HOLT *ET AL.*; 2016 [18]	Joint Position Sense
LIGHT *ET AL.*; 2016 [26]	Integrated Balance Assessment through the Berg Balance Scale (BBS)
KATRANCHA *ET AL.*; 2015 [19]	Wii Balance Board (WBB), avaliação associada à Berg Balance Scale (BBS) e FES-I
SCHOENE *ET AL.*; 2013 [15]	Physiological Profile Assessment (PPA)
VOGLER *ET AL.*; 2012 [27]	Physiological Profile Assessment (PPA)
KIM *ET AL.*; 2014 [25]	Proprioception Test (PT)
LIU *ET AL.*; 2012 [20]	Ankle Joint Position Passive Matching Test
SADEGHI *ET AL.*; 2017[16]	Biodex Isokinetic Dynamometer
ZHENG *ET AL.*; 2013 [21]	Joint Position Sense Test
TREML *ET AL.*; 2013 [17]	Evaluation Integrated with functionality (BBS, FES-I, Functional Reach Test)
CARVALHO *ET AL.*; 2015 [23]	SHORT PHYSICAL PERFORMANCE BATTERY (SPPB)
CABREIRA *ET AL.*; 2014 [24]	Assessment Integrated with postural balance using a force plate (EMG System by Brazil)
NASCIMENTO *ET AL.*; 2012[22]	ASSESSMENT INTEGRATED WITH THE BALANCE THROUGH BERG BALANCE SCALE (BBS)

DISCUSSION

All studies aimed to improve outcomes related to the prevention of falls in the elderly due to the high risk of morbidity and mortality among them.

Regarding the definition of proprioception, the first researcher to approach the subject was Sherrington, in 1900, [29] observing the presence of receptors in the joint capsular structures. Nowadays, it is known that the term is quite complex due to its relationship with the Osteomioarticular System and Nervous System, besides the components that involve the balance. Furthermore, this somatosensory system is closely related to the visual and vestibular system to carry the necessary inputs to the central system. All this scope, in the scientific literature, causes a huge variability of methods for measurement, protocols and definitions to refer to this subject.

The amount of sampling "n" was one of the items observed that didn't show a uniformity in relation to the number of participants selected to obtain the results. Some studies had an "n" above 60 participants and those that had gotten high score on the PEDro Scale (score = 8) recruited participants over 100.

Riva *et al.* (2019) [13] and Liu *et al.* (2012) [20] agree in assuming that one of the limitations of their studies was the size of the sample, and since they were small (61 and 60, respectively), according to them, conclusions couldn't be accurate, just as an analysis involving age classifications and functionality should require a larger number of participants.

Three articles [14], [15], [27] performed proprioceptive measurement through the risk of falls by the Physiological Profile Assessment (PPA) in which visual, proprioceptive, muscle strength and postural balance measurements are taken into consideration in five sensorimotor tests, they are: (I) the Melbourne Edge Test; (II) a lower limb-matching task to assess proprioception with errors in degrees recorded, using a protractor marked on a vertical clear acrylic sheet placed between the legs; (III) measurement of quadriceps muscle strength in dominant lower limb (patient sitting in hip and knee flexion at 90 degrees); (IV) usage of a light as a stimulus for measuring finger pressure reaction time and (V) recording body displacement at pelvic level with participants standing on a rubber foam mat with eyes open [30].

Some studies, [18], [20], [21], evaluated the proprioception through the Joint Position Passive Matching Test in which participants had to place the joint in the same position previously established by the researchers, without the audio-visual aid of them.

In research with the elderly, balance (static and dynamic) is closely linked to the somatosensory system. Zheng *et al.* (2013) [21] states that with age these abilities tend to reduce and become even more difficult to control, resulting in an increased risk of falls, regardless of associated musculoskeletal or neurological pathologies.

The visual system is also part of this whole process. Studies listed in this systematic review have shown the importance of it [13], [14], [25], [21], where the responsibility for space perception, distance and external local hazards have been weighted in their researches.

In trial by Kim *et al*. (2014) [25] randomly divided 30 healthy elderly aged 65 and over into two groups: Visual Block Group (VB) and Visual Permission Group (VP) and after 4 weeks of the intervention, it could be measured that the VB group showed significant changes in the proprioceptive test.

In synergism, Riva *et al*. (2019) [13] also presented as objective of their study, increased proprioceptive control and optimization of vision contribution through high frequency proprioceptive training, obtaining significant results ($P < 0.001$) for postural and proprioceptive control.

Authors assert that when visual senses are blocked, the muscle reaction is primarily organized and postural control is performed more rapidly because the maintenance of the vestibular and proprioceptive senses increases the capacity of the postural control system [25], [31].

Still regarding the connection between the vision system and the proprioception system, Liu *et al*. (2012) [20] detected that the sense of the left ankle joint position was better than the right ankle in the basic values of the three groups studied (Tai Chi group "TC", group that did proprioceptive exercises "PE" and the control group). Thus, as data obtained in the study Zheng *et al.* (2013) [21], in which training group (conventional exercise plus proprioception and cognitive exercise) was better when needed in proprioception of the left knee. Scientific researches justify that the left limb – right cerebral hemisphere, is more conducive to proprioceptive processing than right limb – left cerebral hemisphere, which would be more related to the decoding of visual information due to the specificity of sensorimotor control performance [32].

About the maintenance or loss of the outcomes in the short or medium time, only one study developed by Vogler *et al*. (2012) performed follow up [27] to detect loss or maintenance of results achieved after 12 weeks of intervention stopped. They divided the study into three groups, Weight-Bearing (WB) exercises ($n = 60$), Seated Resistance (SR) exercises ($n = 60$), or Social Visits ($n = 60$) and after this design, it was observed that the Physiological Profile Assessment (PPA) for the SR and WB groups returned to basal values after 12 weeks of suspension. The importance of these discoveries in clinical practice was quoted

for the relevance of the elderly to remain in long-term exercise programs or to be under the supervision of professionals to prescribe home exercises.

In this context of the importance of continuity of treatment, there is a scientific interest in investigating how virtual game technology by providing real physical motion (Exergames) can influence proprioception and factors that decrease the risk factors for falls in this kind of population [14], [15], [16], [17]. The interactivity, audiovisual feedback and the commitment to exercise practice were also some of the additional issues related to the use of exergames as a beneficial intervention to the studied group, in addition to the feeling of well-being provoked, as reported by Treml *et al*. (2013) [17] and Sadeghi *et al*. (2017) [16] in their studies.

Considering that many elderly also have neuropsychological factors involved in their aging process, Schoene *et al*. (2013) [15] and Gschwind YJ (2015) [14] approached that the playfulness of the activity when performed at home can be more comfortable in the daily routine and personal satisfaction when performing them. Liu *et al.* (2012) [20] also stated in their study that choosing a differentiated activity (Tai Chi) expresses more interest and satisfaction in the elderly than when a conventional intervention was chosen. However, the fact that handling depends on technological knowledge and skills about navigation to solve specifics problems; when these problems emerged, they cause difficulties and need technical support. Gschwind *et al.* [14] reported offering broad support to participants in two intervention groups: 91 participants for the Randomized Controlled Trial (SMCT) with Exergame SMT and 57 participants for the KIN RCT. Such situation, however, caused a reduction of adhesion due to difficulty of usage. One suggestion of the authors was the development or reformulation of exergames more adapted to the elderly population.

CONCLUSION

This study had some difficulties that were highlighted during its development: I) randomized studies that provided the full text only in the paid database were not included in this systematic review; II) difficulty in dissociating information related to the somatosensory system, due to its physiological connection with other components; III) Due to the great variability of the methods of the assays analyzed, it was not possible to accurately conclude parameters that should be adopted for future studies.

In addition, it can be seen the importance of sensorimotor training in the elderly as an intervention to reduce the risk of falls in the elderly, as well as helping to guide new related studies, providing scientific subsidies to professionals working in the sensorimotor area to improve clinical and methodological results.

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