

Effect of dance on lower-limb range of motion in young people with cerebral palsy: a blinded randomized controlled clinical trial

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Purpose: One of the most limiting conditions in cerebral palsy (CP) is the impairment in musculoskeletal mobility. CP may impair the ability to perform efficient movements. The aim of this trial was to investigate the effect of dance on the range of motion (ROM) of lower limbs in young people with CP.

Patients and methods: the randomized clinical trial consisted of two groups: dance group (DG) and control group (CG). Both of them underwent a 1-hour treatment, twice a week, for 2 months. Sanny® pendulum fleximeter was used to measure ROM in pre- and posttreatment. The applied procedures in both groups were conducted at suitable locations. Twenty-six participants were allocated to these two groups of study.

Results: In DG, the sampling variances showed improvements in all lower limb joints and axes of movements ($P < 0.05$). In CG, there was increase in passive ROM in some lower limb joints ($P \leq 0.05$).

Conclusion: Physical intervention is imperative to improve ROM. It seems dance practice can contribute to CP corporal mobility in a positive way.

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Keywords: dance, physical therapy, cerebral palsy, range of motion

Introduction

Cerebral palsy (CP) is a neurological dysfunction that may impair the ability to produce normal levels of range of motion (ROM) and muscular strength.¹⁻³ Hypertonicity is a neurological sign of brain damage or motor dysfunction characterized by an increase in tonic stretch reflexes associated with enlarged tendon spasms resulting from hyperexcitability of the stretch reflex.^{4,5} Besides, hypertonia – result of injury to the central nervous system (CNS) – may interfere with patient movement or positioning and then promote pain and discomfort.²

This condition also causes other functional impairments such as abnormal postures, excessive activation of antagonistic muscles, and stereotyped movements associated with muscle synergies that difficult various movements as locomotion.³⁻⁶

Biomechanical impairments are predictors of difficulties in functional balance in several health conditions. The reduced ROM interferes with CP physical function, and deficits in neuromuscular control increase risk of injuries.⁷ In this view, it is fundamental to assess ROM in CP patients to conduct therapeutic approaches that minimize ROM impairments. Evidence highlights the importance of the goniometry as a method of ROM measurement in hypertonia, as it is performed judiciously by two examiners.⁷⁻¹⁸

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Approaches focusing on walking training in CP have been reported. Functional exercises and circuit-training approaches have proven to be beneficial in contributing to and promoting functionality and mobility in CP.¹⁹ Previous research has elucidated the benefits of rhythmic activities, such as dance, to promote optimizations in motor control and function, because these activities can stimulate responsible systems for interaction of movement, increasing joint mobility and body balance.^{4,20–25}

Unfortunately it is unclear how dance intervenes in hypertonia, although some neuroimage studies highlighted the influence of dance in cerebral areas responsible for motor planning, movement control and activating systems, such as the action observation network. In addition, dance practice promotes different effects in white and gray matter.^{6,27–31}

Besides, dance practice activates brain connections that influence neuroplasticity by connecting several areas of brain associated with perception, emotion, and motor planning.^{20,23,24,26–31} Some researchers claim neuromuscular actions are intertwined with perception and cognition processes, and the ability to perform tasks is directly related to its interaction with environment, and that determines its functional capability.^{25,32–36}

To our knowledge to date, there are limited studies that have investigated dance as a possibility to increase ROM in affected joints by muscle hypertonia. This has led to an interest further investigations into the benefits that dance can have on promoting ROM in CP participants. Thus, the aim of this study was to examine whether dance helps to reduce joint, tendon, and muscle strain, and whether it influences ROM in young people with spastic CP.

Patients and methods

This study was carried out in accordance with the principles of the Declaration of Helsinki. We declare that this study was approved by the Ethics Committee of Federal University of Sergipe (approval number CAAE-06154012.4.0000.0058-12 and number 98.993) and informed consent form was signed by the participants.

Study design

This study was a controlled and randomized clinical trial. After signing the informed consent, participants were randomly enrolled into two groups according to a computer-generated randomization sequence: 1) dance group (DG) and 2) control group (CG).

Before the study commenced, the enrolled participants were enrolled into a computer generated system to achieve randomization. A blocking randomization was performed to

generate a sequence of allocation to ensure that there was a close balance of the numbers in each group at any time during the study. After every block, the number of participants in each group would be equal, that is, in a 1:1 ratio.

Participants

Inclusion criteria were as follows: young people with CP; gross motor function classification scale (GMFCS) III–V; both sex; age between 15 and 29 years; muscle hypertonia at the passive movement examination; do not attempt any other physical activity or physical therapy during protocol; do not exhibit cardiopathy or neoplasia. Exclusion criteria were cognitive or psychiatric disturbances and withdraw from study.

Participants were randomly allocated in one of the following groups: DG was composed of young people with CP who attended dance classes, and CG was composed of participants with CP who attended physical therapy sessions.

An estimated intended size sample bias to study groups was fixed using the demographics data of the first 12 subjects involved in the study. An α value of 0.05 and a power of 75% indicated a size sample bias of 12 participants from both groups.

Ethics statement

All participants' parents signed informed consent for participation in this study and the study was approved by the Ethics Committee of the Federal University of Sergipe.

Experimental protocols

Dance group (DG)

This group received a specific dance protocol (called Técnica Aplicada Lavinia Teixeira [TALT]) based on the concepts of Bartenieff, Feldenkrais, and Laban methods. A total of 24 1-hour sessions were conducted twice a week, for 3 months. Four sets with eight repetitions for each procedure were performed as follows:

1. Global ROM: coordinated and rhythmic dynamic activities in the ROM through floor exercises
2. Motor coordination: coordinated movements of upper and lower limbs emphasizing opposite directions
3. Body image: interaction between practitioner and environment (space -temporal orientation), association of simultaneous components of the movement (temporal coordination), and proprioception (inside knowing/movement perception)
4. Skill and agility: linkage of sequential components of the movement (anticipatory adjustments in the movement

course) and movements of trunk and head to aid spatial orientation and stimulate equilibrium notions^{36–38}

Control group (CG)

The CG received physical therapeutic exercises, including neurodevelopmental treatment (NDT) and proprioceptive neuromuscular facilitation (PNF) methods, for 1 hour, twice a week, for 3 months, i.e., 24 sessions in total.^{39–41} Four sets with eight repetitions for each procedure were performed:

1. Global ROM with passive and active stretching exercises
2. Motor coordination: coordinated movements of upper and lower limbs emphasizing opposite directions and the proposed diagonals through PNF method
3. Body image: space–temporal orientation, dynamic activities according to NDT
4. Skill and agility: proprioception activities; association of more than one movement to instigate flowing movement with PNF.

Assessment instruments

Social demographic data

An enrollment form was used in baseline to collect demographic data (name, age, weight, scholarship, job, marital status, general characters, history of disease, and preceding familiar, physiologic, and social histories) and to record information about functional activities of participants.

Range of motion (ROM)

Degree of passive ROM was assessed by Sanny® pendular fleximeter. This measurement was performed twice, pre- and posttreatment. Two trained examiners measured the angular measurements at each stage of the study to compare possible variations between the analysis, which was used to determine mean angles among patient groups.

The procedure was repeated in both groups and in both times of sampling.²⁰

Movements were assessed bilaterally in the frontal, sagittal, and transversal planes. Hip joint: flexion (flexion of hip with knee in flexion and extension), extension, abduction, adduction, and external and internal rotation; knee joint: flexion and extension movements; ankle joint: dorsal flexion, plantar flexion, abduction, adduction, inversion, and eversion.^{5,12,22}

Protocol procedure

The procedure applied in the DG was performed in a dance class with parallel bars, mirrors, and sound equipment. The procedure applied in the CG group was performed in a suitable ambulatory for physical therapy (Figure 1).

Statistical analysis

The Shapiro–Wilk test was used to verify normality. All variables presented normal distribution. Descriptive analysis of demographic data and differences between intra- and intergroups (independent *t*-test) were analyzed using SPSS program, version 22.0 (IBM Corporation, Armonk, NY, USA). Data were represented as mean and standard error of mean. Significance was set at $P \leq 0.05$.

Results

Thirty-three participants were eligible to participate in the study. Two subjects were excluded from the study because they were <13 years of age. Thus, the study began with 31 participants. During the implementation of protocols, two participants concluded physical therapy sessions and other two gave up participating in the study. Twenty-seven participants were distributed into two study groups. Fourteen participants, seven women and seven men, were allocated to physical therapy group (CG). Thirteen participants, seven women and

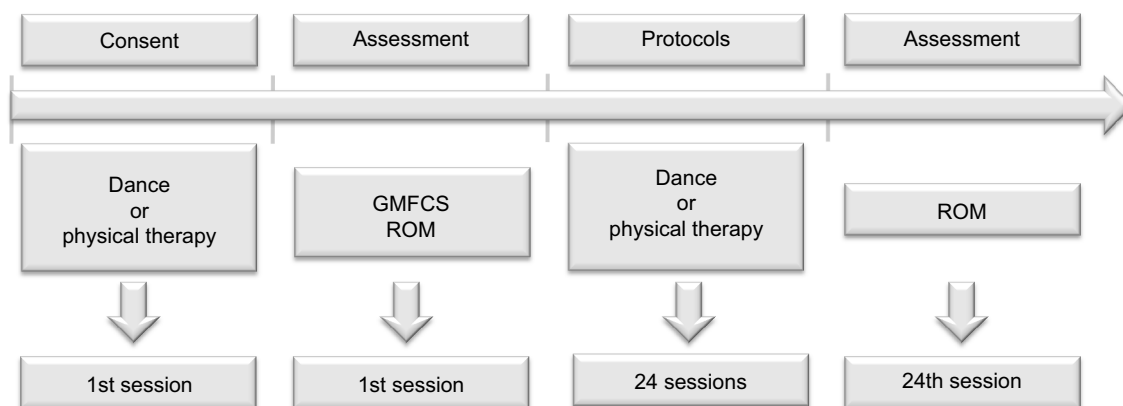


Figure 1 Timeline of the study.

Abbreviations: GMFCS, gross motor function classification system; ROM, range of motion.

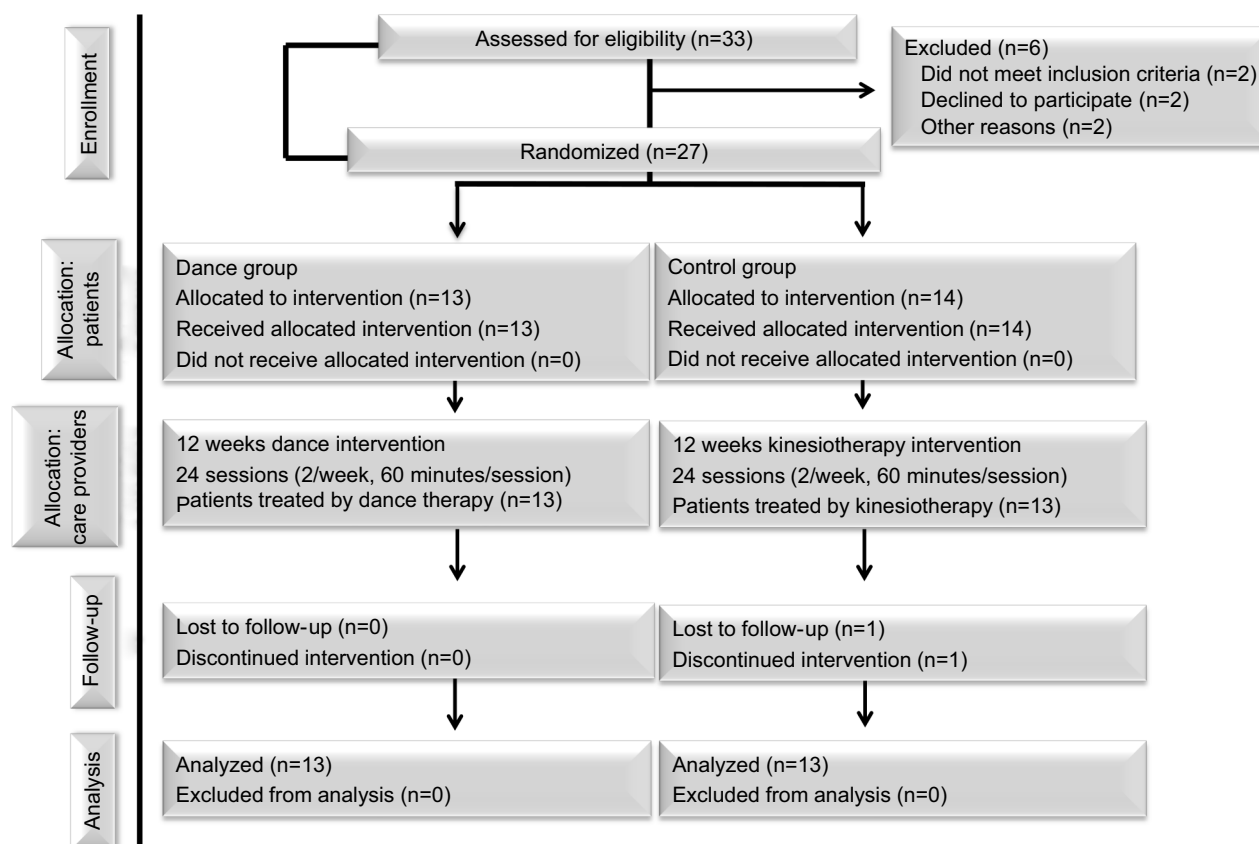


Figure 2 Flow diagram of the study.

six men, were allocated to DG (Figure 2). Sociodemographic data were similar in both groups at baseline (Table 1).

Table 2 describes the movements of the lower limbs of participants in both groups. After treatment, CG showed increase in ROM of the hip for extension ($P=0.007$, right and $P=0.01$, left), adduction ($P=0.01$), internal rotation ($P=0.03$, right and $P=0.002$, left), and left external rotation ($P=0.05$) and ankle joint, dorsal flexion ($P=0.02$, right and $P=0.03$, left), right plantar flexion ($P=0.01$), and eversion ($P=0.0001$, right and $P=0.01$, left) improvement adduction on the left hand side and inversion on the right hand side. In DG, compared to baseline, passive ROM in all axes of motion of hip, knee, and ankle joints increased. In the intergroup comparison, DG showed improvement in all axes of motion, except for hip left flexion (with knee extended) ($P=0.16$) and hip right extension ($P=0.08$).

Discussion

Findings showed impairment in all lower limb joints in both groups. For instance, 30 degrees in hip passive flexion

Table 1 Descriptive and anthropometric characteristics of participants at baseline

Baseline data			
	Dance group	Control group	P-value
	N=13	N=14	
Age (years)	14.00 (3.46)	15.07 (2.36)	0.50
Gender	3 M, 10 F	7 M, 7 F	
Height (m)	1.38 (0.13)	1.39 (0.16)	0.78
Weight (kg)	43.15 (10.71)	42.18 (10.65)	0.72
BMI (kg/m ²)	22.19 (2.02)	21.49 (2.57)	0.43
GMFCS			
Levels	Dance group	Control group	
I	–	–	
II	–	–	
III	3	5	
IV	3	4	
V	7	5	

Notes: GMFCS levels: I, walks without limitations; II, walks with limitations; III, walks using a hand-held mobility device; IV, self-mobility with limitations; may use powered mobility; V, transported in a manual wheelchair. Mean (SD) and P-values. t-test for independent samples.

Abbreviations: F, female; GMFCS, gross motor function classification system; M, male.

Table 2 Participants' passive lower limbs range of motion, pretreatment, and posttreatment in both groups, control and dance

Joint	Movement	Control group				Dance group				Paired difference	
		Before		After		Before		After		P-value	Before After
		Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range		
Hip	Right flexion (flexioned knee)	56.92 (9.10)	30–120	56.53 (8.36)	30–120	53.07 (7.64)	30–100	82.69 (4.79)	50–125	0.0001†	0.77 0.04*
	Left flexion (flexioned knee)	58.46 (8.21)	30–100	58.84 (7.44)	35–120	56.23 (7.91)	30–100	92.69 (5.59)	70–125	0.0001†	0.86 0.01*
	Right flexion (extended knee)	43.46 (5.16)	30–60	46.53 (5.35)	30–90	43.07 (6.16)	20–90	61.15 (4.63)	40–95	0.0006†	0.96 0.03*
	Left flexion (extended knee)	44.61 (5.84)	30–95	45.38 (5.32)	30–90	45.76 (6.32)	30–100	56.53 (5.61)	40–105	0.0002†	0.89 0.16
	Right extension	10 (0.80)	5–15	12.30 (0.91)	10–20	12.30 (2.01)	5–30	16.53 (2.07)	10–30	0.0008†	0.27 0.08
	Left extension	9.61 (1.19)	5–20	12.69 (1.45)	10–25	10.38 (1.74)	5–30	16.92 (1.74)	10–30	0.001**	0.71 0.05*
	Right abduction	21.15 (1.71)	15–35	18.07 (1.44)	15–25	21.92 (3.07)	10–40	33.07 (2.86)	10–50	0.007**	0.83 0.0006†
	Left abduction	22.03 (1.84)	10–35	23.07 (1.74)	15–30	26.92 (3.46)	10–40	35.15 (3.78)	10–55	0.0001†	0.29 0.02*
Knee	Right adduction	13.46 (2.29)	5–30	15.38 (2.62)	5–35	11.15 (2.27)	5–35	22.92 (1.91)	10–35	0.03*	0.52 0.02*
	Left adduction	12.69 (2.08)	5–30	17.30 (3.08)	5–40	12.15 (2.58)	5–35	25.76 (1.94)	15–40	0.04*	0.88 0.02*
	Right internal rotation	19.61 (1.99)	10–30	21.15 (1.97)	15–35	21.92 (2.37)	10–30	30.38 (3.64)	10–65	0.002**	0.38 0.01*
	Left internal rotation	20 (1.49)	10–30	23.84 (1.51)	15–35	23.07 (3.02)	10–30	31.53 (3.12)	10–55	0.001**	0.30 0.01*
	Right external rotation	19.61 (1.99)	10–35	20.38 (1.91)	15–40	23.46 (1.63)	10–35	32.30 (2.23)	15–40	0.0002†	0.61 0.0009†
	Left external rotation	20 (1.49)	10–35	21.92 (1.55)	15–40	20.76 (0.95)	10–35	32.31 (2.23)	20–45	0.0004†	0.71 0.002**
	Right flexion	114.61 (5.50)	90–140	120 (4.04)	100–140	113.07 (3.77)	90–140	132.30 (3.23)	100–150	0.0001†	0.78 0.05*
	Left flexion	112.38 (6.23)	90–140	123.46 (4.94)	100–140	115 (5.15)	90–140	133.84 (2.72)	100–150	0.0008†	0.51 0.05*
Ankle	Right extension	110 (4.38)	90–130	112.30 (5.20)	80–130	113.46 (4.43)	90–135	127.30 (3.56)	95–140	0.0002†	0.60 0.05*
	Left extension	114.55 (4.54)	85–140	120.23 (5.34)	100–150	117.69 (5.73)	85–140	132.34 (3.08)	100–140	0.003**	0.54 0.05*
	Right dorsal flexion	8.46 (1.43)	5–20	13.07 (1.20)	5–20	9.61 (1.32)	5–20	19.61 (2.91)	10–35	0.0003†	0.59 0.04*
	Left dorsal flexion	8.84 (1.71)	5–25	14.23 (1.11)	10–25	9.23 (1.36)	5–20	20.38 (2.74)	10–40	0.0001†	0.85 0.04*
	Right plantar flexion	21.15 (1.89)	10–40	26.15 (1.61)	15–35	21.53 (1.63)	15–30	35.38 (2.15)	25–45	0.006**	0.88 0.004**
	Left plantar flexion	22.69 (1.56)	15–30	24.23 (0.76)	20–30	21.58 (1.31)	15–30	35.81 (2.52)	25–45	0.01*	0.63 0.0008*
	Right inversion	19.23 (1.24)	10–20	21.15 (1.80)	10–30	17.30 (2.23)	10–20	27.30 (1.56)	20–35	0.0006*	0.46 0.006*
	Left inversion	17.69 (1.92)	10–20	23.07 (1.65)	10–30	18.46 (2.07)	10–25	28.07 (1.55)	20–35	0.007*	0.75 0.04*
	Right eversion	13.46 (1.82)	5–30	21.92 (2.00)	10–35	14.23 (2.32)	5–35	29.61 (1.99)	15–35	0.02*	0.82 0.0008*
	Left eversion	16.15 (1.80)	10–30	21.23 (1.33)	10–35	16.15 (1.80)	10–30	29.38 (1.91)	15–35	0.03*	0.90 0.0008*

Notes: Data are expressed as Mean (SD), t test for dependent and independent samples. *P<0.05, **P<0.009, †P<0.0009. Bold values represent statistical significance.

indicates reduced ROM, and consequently, difficulty to perform simple movements, such as transfer changes. Results of this study showed increased ROM in posttreatment. Participants who attended dance classes showed better increase in appendicular ROM.

Dance practice promotes positive effects in special circumstances, including physical disorders. Some studies investigated the influence of dance in joint mobility in various patient groups; Parkinson's disease,³ rheumatoid arthritis,⁴² treatment of breast, and lung cancer¹⁹; and the elderly.²⁴

Similar to our findings, several researchers have elucidated the effects of dance on ROM in various disorders.^{3,10–13,17,20,22,32,35,36,38,42–45} Dance involves intentional movements, which supports the findings of our study that it increases ROM of lower limbs, as well as its influence on the movements of head, trunk, and upper limbs were also studied.

Dancing can help increase ROM through movement control, escape, or distraction from pain and stress, change in emotion, state of consciousness, and/or physical ability. Additionally, dance practice can promote health by restoring the bodily system through muscular action and psychological processes, as well as conditioning awareness through movement.

Image studies elucidated the influence of dance practice on cerebral areas that connect motor control and subjective processes. A peculiarity of dance is the possibility of investigating neuronal plasticity and its interaction with behavior. Research suggests that long-term dance practice positively affects brain activity in observation and simulation networks, substantially modifying white and gray matter in various brain regions. Dance integrates several brain functions such as kinesthetic (perception of one's own body movement), musical (interpretation of sound), and emotional (the extent to which music and movement express).^{25–30}

Whereas chronic nonprogressive disorders of movement and posture are characterized by a lack of control over the movements that cause muscular weakness and selective loss of motor control,^{25,36} dancing can provide attributes to minimize muscular shortenings dishevel in the corporal biomechanical because of ROM limitation.^{2,41,46} Dance practice protocol used in this study focused on musculoskeletal and movement impairments, highlighting movement potential of each participant.

A range of studies have described the the importance of ROM evaluation in movement disorders and their applicability in the approaches for effectively improving range of motion. Assessing ROM allows a careful investigation of changes in joint mobility and early verification of

contractures and deformities, which impair mobility and functional independence.

Participants of our study already presented with many contractures and deformities; we verified ROM deficits and GMFCS levels based on which they were classified. Only a few studies have highlighted these factors in the CP functionality. Researchers usually suggest surgical procedures that compromise the integrity of musculoskeletal structures, in addition to the risks that the patient runs through such interventions.

We had the opportunity to include the participants in a show of a dance school in the theater. This fact had an overwhelming repercussion in the social scope of these participants: being on a stage, in a prominent position, seeing people watching the presentation, perceiving audience enthusiasm with the dance performance, and then receiving standing applause, in addition costumes and stage lighting were among other peculiar characteristics that are awakened in the dance scene were determining factors for the findings. Most of all, we had participants' adherence throughout the study, because the dance program triggered a paramount human need in these young people with CP: the sense of belonging.

Therefore, we suggest dance practice in CP cases to promote motor action for inciting favorable levels of ROM. Dancing seems to contribute to body management due to cognitive and motor connection.

Conclusion

Dance practice can help mobility of young people with CP, and it represents an approach option in kinetic disturbances intervention. Dancing allows the patients to experience communication through the movement of their bodies, and its practice provides individuals to express their feelings, their thoughts and their actions in different ways.

Thus, individuals with neurological and motor disabilities, that present difficulties in expressing their individuality in the face of society, can benefit from dance practice. This is because dancing promotes self-esteem, self-confidence, and well-being, which are factors that are essential for psychomotor performance. This can be further justified by our study findings about increased ROM in all joints in the DG, despite a short period of intervention.

Data from this study suggest future research covering a longer time of intervention to evaluate applicability. New studies are also necessary to investigate the influence of dance practice on joint, tendon, and muscle stress in young people with CP. Studies will also need to evaluate whether

this intervention alters or maintains skeletal muscle structures in this population.

Data sharing statement

We do not intend to share individual deidentified participant data. We will share ROM data included in this study. We can share study-related documents, such as photos or videos of participants. When necessary, we can provide our data for further investigations.

Disclosure

The authors report no conflicts of interest in this work.

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