Research Square

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Inclusion Strategies: A Trampoline Program For Children With Autism Spectrum Disorder

Carla Lourenço (ccvl@ubi.pt)
University of Beira Interior: Universidade da Beira Interior
Dulce Esteves
University of Beira Interior: Universidade da Beira Interior

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Abstract

Background: Autism Spectrum Disorder (ASD) is a neurological disorder that is characterized by deficits in social, communication, and motor function. Trampoline-based interventions reported to promote motor proficiency in children with ASD to foster the development of coordination, balance and muscle strengthen.

Methods: This study examined the effects of two trampoline interventions on the motor skill proficiency, muscle strength of the lower limbs, and body mass index (BMI) of 25 children (aged 6.9 ± 2.3 years) with ASD. The 20-weeks intervention participants (n=6) are in the experimental group A, whereas the 32-week intervention participants (n=8) are in experimental group B. The control group consists of 11 participants who did not receive any intervention constituting.

The Bruininks–Oseretsky Test of Motor Proficiency-2 (BOT-2), the Standing long jump, and BMI assessment were conducted three times for each participant at baseline (T1), middle time of the intervention (T2), and post-intervention (T3).

Results: The findings suggest that children in both experimental groups exhibited significant improvements in BOT-2 and the standing long jump after the 20-weekand 32-week of trampoline-based physical activity intervention when compared to the children in the control group. No significant difference was found on BMI before and after the interventions in all three groups.

Conclusion: The findings provide supporting evidence that a minimum 20-week trampoline training may be a viable therapeutic option for training children with ASD to improve their motor proficiency.

Introduction

Seven decades have passed since Leo Kanner's classic description of the syndrome early infantile autism (Volkmar, Reichow, & McPartland, 2012).Over the years, the concept has undergone some changes (Volkmar & McPartland, 2014). Currently, the name Autism Spectrum Disorder (ASD) is more commonly used. It consists of neurodevelopmental disorders that create deficits in communication and socialization, restricted interests, and repetitive behaviours (Worley & Matson, 2012). Children with ASD have dysfunctional sensory profile (Tomchek & Dunn, 2007) may lead to difficulty attending to and processing sensory stimuli. (Kern et al, 2006; Piek & Dyck, 2004).

Recently literature confirm the existence of motor deficits in children with ASD (McPhillips, Finlay, Bejerot, & Hanley, 2014). Gizzonio et al. (2015) suggest that motor deficits can be divided into the basic motor control (coordination, gait, posture and muscle tone) and motor performance deficits. However, Whyatt & Craig (2012) state that the specific motor deficits associated with ASD cannot be generalized and are more evident in the most demanding activities. Also, Staples, MacDonald and Zimmer (2012) state that children with ASD demonstrate poor motor performance, and this becomes more persistent with an increase in age. Individuals with ASD has, frequently, sensory deficits whose help to understand some of their abnormal behaviours (Posar & Visconti, 2018). One of the strategies to improve motor deficits is use physical activity-based intervention. In fact, it was reported that physical activity programs may provide benefits for children with ASD (Lang et al.2010; Lawrence, Esteves, Corredeira & Seabra, 2015; Sowa & Meulenbroek, 2012;) and can be an excellent remedy for counteracting some of the impairments they present. The effects of physical activity interventions such as walking/hiking (Petetti et al., 2007; Todd & Reid, 2006), swimming (Pan et al., 2006; Pan 2010), running (Fragala, Haley & O'Neil, 2011; Petrus et al., 2008; Rosenthal-Malek & Mitchell, 1997) and hippotherapy (Bass, Duchowny & Llabre, 2009; Ajzenman, Standeven & Shurtleff, 2013; Gabriels et al., 2012), have been supported by previous literature and suggested that an improvement of motor proficiency in children with ASD stems from the participation in physical activity intervention (Wrotniak, Epstein, Dorn, Jones & Kondilis, 2006).

Children with ASD show lower levels of physical activity and higher levels of sedentary behaviour (Jones et al., 2017), so it is recommended that the proposed intervention activities for children with ASD need be physical activities that are challenging, stimulating, and fun like trampoline because having a valuable playful component (Lourenço et al., 2015). children with ASD, It has been reported that use of trampolines in the interventions has resulted improvements in children’s balance and motor performance (Giagazoglou et al., 2013; Giagazoglou et al., 2015), postural control (Apoloni, 2013), and strength (Atilgan, 2013). In addition, trampolines present a motivational, enjoyable, and gratifying facet that can attract children with ASD to participate and provide at the same time benefits in cognitive, psychosocial, coordination, balance and agility aspects (Lourenço & Esteves, 2018). Therefore, trampoline training was selected as the intervention activity for children with ASD in this study. The purposed of this study was to examine the effects of trampoline-based intervention for children with ASD on motor proficiency, BMI and jumping distance.

It was hypothesized that children in the experimental group would improve their motor proficiency, jump distance, and BMI after the 20-32-week intervention as compared to the children in the control group.

Methods

2.1 - Experimental design

This study was a within-participant repeated-measures design with two experimental groups: Experimental Group A (EGA), children with ASD participated in a 32-weeks intervention program; Experimental Group B (EGB), children with ASD participated in a 20-weeks intervention. Children in the control group (CG), did not participate in the intervention.

All participant was assessed three times, beginning of the study as baseline (T1), a half way through the intervention (T2), and after the intervention (T3).

2.2 - Participants

Children with ASD were recruited through the Portuguese Association for Autism Spectrum Disorders (APPDA).The families were contacted via telephone and parents were invited to give permission for their child to participate. The informed consent was obtained for all children prior to their participation in the study.

Children were randomly assigned to the experimental group A (EGA, n = 6, add average age and gender), experimental group B (EGB, n = 8, add average age and gender),) and the control group (CG, n = 11, add average age and gender). All participants were diagnosed with ASD.

In an effort to obtain a homogenous sample, recruitment was restricted to participants rated as high-functioning on the ASD, according to assessments by psychiatrists and physicians in the hospitals and identifications as meeting the American Psychiatric Association Diagnostic and Statistical Manual of Mental Disorder (American Psychiatric Association, 1994) criteria for autistic disorders or Asperger's syndrome. Families were eligible to participate in the study if they met the following criteria: (a) at least one child with ASD in the household, (b) child age 4 and 11 years old, (c) no other medical condition, and (d) child was able to follow instructions. The final sample consisted of 25 children with ASD. Descriptive statistics on the participants and diagnosis are presented in Table 1.

Table 1
Characterization of experimental groups A and B and the control group

Subject	Gender	Age (years)	Weight (Kg)	Height (cm)	BMI	Percentile BMI
EGA						
1	F	4	18.3	104	16.9	90
2	M	6	22.7	119	16	75
3	M	10	42	152	18.2	75
4	M	9	40.3	139	20.9	95
5	M	7	37.2	140	19	95
6	M	8	23.4	125	15	50
Average (DP)			32.1 ± 10.8	129.8 ± 17.2		
EGB						
7	M	5	18.9	111	15.3	50
8	M	8	25.3	127	15.7	75
9	M	7	27.4	125	17.5	90
10	M	4	18.9	104	17.5	95
11	M	4	19.6	109	16.5	85
12	M	4	16.6	104	15.3	50
13	M	4	27	119	19.1	97
14	M	5	16.6	111	13.5	3
Average (DP)			21.2 ± 4.5	113.7 ± 8.9		
CG						
15	F	6	24.5	123	16.2	75
16	M	6	22.2	113	17.4	90
17	F	7	23.3	121	15.9	75
18	M	11	30.8	134	17.2	50
19	M	9	41	144	19.8	95
20	M	8	28.9	134	16.1	75
21	M	11	37.3	150	16.6	50
22	M	8	29.7	130	17.6	85
23	M	8	38.6	141	19.4	95
24	F	4	13.6	96	14.8	50
25	F	10	54.6	138	28.7	97
Average (DP)		6.9 ± 2.3	34.1 ± 17.1	131.5 ± 18.6		

EGA intervention underwent 32 weeks of the training program, while EGB had 20 weeks of training. The children in the experimental groups (EGA and EGB) participated in a weekly session of 45 minutes on trampoline training for either 20-week or 32-week, whereas the children in the control group were not introduced with any intervention activities. All participants (including control group) continued to participate in their school activities.

2.3 – Parameters evaluated

2.3.1 – Body Mass Index (BMI)

The anthropometric measurements were evaluated according to the international standards for anthropometric assessment (Marfell-Jones et al., 2006). The participants were barefoot for the weigh-in, which was measured using a digital scale (Seca, model 841, Germany), with an accuracy of 0.1 kg. Height was measured with a stadiometer of approximately 0.10 cm (Seca, model 214, Germany).

2.3.2 – Motor Proficiency

Motor proficiency was assessed by the Motor Proficiency Test of Bruininks-Oseretsky-2(2005), in its reduced form (BOT-2), which had been used on this population previously (Dewey, Cantell & Crawford, 2007; Gabriels et al., 2012; Mattard-Labrecque, Ben Amor, & Couture, 2013). The reduced form of the battery is composed of a set of 12 structured items in 8 subtests, which were used to assess each child individually.

Table 2
Subtests of the Motor Proficiency Test of BOT-2 in the reduced form

Subtests
Subt.1- Fine Motor Precision - Colour a star - Draw a line through a path
Subt.2 – Fine Motor Integration - Copy two circles - Copy two inverted squares
Subt.3 – Manual Dexterity - Stringing
Subt.4 – Bilateral Coordination
Subt.5 – Balance - Walk on a line
Subt.6 – Speed and Agility - Jump on one foot
Subt.7 – Coordination of Upper Limbs - Throw and Catch the ball - Dribble a ball, alternately
Subt.8 – Strength - Push-ups

2.3.3 – Muscle Strength of the Lower Limbs

To evaluate the muscle strength of the lower limbs, the horizontal thrust jump was performed. Each child was placed behind a marked line on the ground, with the feet slightly apart and parallel to each another, through knee bending and hip flexion, the child attempted to jump as far as possible (Skowronski, Horvat, Nocera, Roswal, & Croce, 2009). The distance between the line on the ground and the rear part of the feet was measured with measuring tape. Three jumps were performed and recorded, and the best result was chosen for each child.

The standing long jump is a reliable test to evaluate lower-body muscular power (Fernandez-Santos et al., 2015; Fernandez-Santos et al., 2018) or lower body muscular fitness (Castro-Piñero, 2010; Costa et al., 2017) and is considered a practical, time efficient, and low in cost and equipment requirements test, with practical use in school based interventions (Costa et al., 2017).

2.4 – Intervention Program

A trampoline-based intervention program was specifically designed for children with ASD, based on the following elements:

- - The initial diagnosis of each child, in order to understand their level of motor development and to adapt the type of exercises to be performed;
- - The individualization of training - only two children were involved simultaneously and avoided external stimuli that would distract the child from the task to be performed;
- - Fun as a motivational factor - the program was based on trampoline jumps. Coloured balls, bows, balloons, animal pictures, numbers, among others were included to increase the fun and the concentration of the children in the tasks to carry out;
- - Requirement in communication - a verbal communication of the actions that were to be performed was required and the development of the language was potentiated;
- - Introduce multitasking to provide cognitive stimulation - while performing motor tasks were posed cognitive challenges (e.g., color or numbers, discovering animals in pictures, discovering hidden objects in the room);
- - Developing relational skills by assisting the child in the exercise;
- - Enhance greater motor control - exercising where imitation was required;
- -Increase motor coordination, both coarse and fine, by specific motor stimulation (jumping on trampolines in different modes);

The experimental groups EGA and EGB had a weekly session of 45 minutes, during 32 and 20 weeks, respectively. Basic equipment used consisted of two mini-trampolines, an elastic bed, a full-size trampoline, and two trampolines of an 80cm diameter.

In the first intervention training sessions, children were introduced to the trampolines and had a time to get familiar with the equipment and different types of jumps. In the following sessions, materials such as balls, bows and strings were introduced. In these sessions, in addition to the jump, other coordinative movements were requested, progressing throughout the planning sessions, increasing the number of repetitions, the level of difficulty and autonomy, and therefore decreasing the amount of help. In the final sessions, other cognitive stimuli, namely colours, numbers, and counting were introduced, in order to coordinate the movement with cognitive and psychomotor reactions.

Another very important aspect to take into account was the exemplification of the task, verifying that the child was attentive and visualizes all the exemplification. Before starting the exercises, a warm-up session was done in order to increase heart and respiratory rate and warm up the different joints.

2.5 – Statistical Procedures

In order to express the different distributions of the values of the variables analysed, we resorted to descriptive statistics (the mean and standard deviation). The Shapiro-Wilk test for normality was used to assume the normality of the distributions which was fulfilled in all of the variables of this study. The analysis of variance (ANOVA) was used at baseline to assess the differences among the three group on BOT-2 scores, BMI, and horizontal jump distance. The repeated measures ANOVA was used to analyse the intervention effects before and after the trampoline-based intervention between children in EGA, EGB and CG. The significance level was set at 0.05. The statistical analysis was performed in SPSS statistical software version 21.0.

2.6 – Ethical Considerations

All study procedures were reviewed and approved by the university ethical committee. Study objectives and methods were individually explained to and written consent and assent obtained from parents and children, respectively.

This research complied with the ethical recommendations that are compulsory to work with minors and all of the principles of the Helsinki Declaration were followed, with special attention focused on the informed consent and the vulnerability of the population studied.

Presentation Of The Results

This study aimed to evaluate the effects of trampoline training programs on motor proficiency, BMI and muscle strength of the lower limbs evolution of children with ASD.

3.1 – Body mass index

Table 3 shows, the results obtained in the evaluation of BMI, for the three groups assessed at three times of the study.

Table 3
Mean values (standard deviation) and ANOVA results of repeated measures of BMI in EGA, EGB and the CG, during the three moments of evaluation.

	EGA			EGB			CG			ANOVA repeated measures		
V	T1	T2	T3	T1	T2	T3	T1	T2	T3	I	G	I*G
BMI	17.6 (2.12)	17.6 (2.06)	17.7 (2.08)	16.4 (1.84)	16.8 (1.98)	16.8 (2.28)	18.1 (3.78)	17.9 (3.57)	17.6 (3.87)	0.706	0.677	0.222
V – variables; BMI – Body Mass Index; EGA – Experimental Group A; EGB – Experimental Group B; CG – Control Group; I – Intervention; G – Group; I*G – Group and intervention; T1 – Baseline; T2 - a half way through the intervention; T3 – after the intervention.												

No statistically significant differences in BMI (p = 0.222) was found before and after the intervention among the three groups.

3.2 – Muscle strength of the lower limbs

The variation of the MSLL after the intervention is shown in Table 4, considering the different stages of evaluation.

Table 4
Mean values (standard deviation) and ANOVA results of repeated measures of the MSLL in EGA, EGB and the CG, during the three moments of evaluation.

	EGA			EGB			CG			ANOVA repeated measures		
V	M0	M1	M2	M0	M1	M2	M0	M1	M2	I	G	I*G
MSLL	66.2 (39.15)	80.0 (47.34)	82.6 (55.97)	23.4 (29.73)	47.4 (38.41)	65.7 (41.14)	79.6 (24.75)	83.6 (24.37)	84.9 (21.56)	0.000	0.055	0.011*
V – variables; MSLL – Muscle Strength of the lower limbs; EGA – Experimental Group A; EGB – Experimental Group B; CG – Control Group; I – Intervention; G – Group; I*G – Group and intervention; M0 – Moment 0, before the intervention; T1 – Baseline; T2 - a half way through the intervention; T3 – after the intervention.												
Descriptive analysis showed that at the baseline (M0), the highest values were recorded in EGA and the CG. It was evident that EGB had lower jumping distance (23.4cm) when compared to the other groups. EGB recorded the largest increase in jump distance during the intervention program. EGA also made some progress, which was more evident between MO and M1. The CG showed some improvements, but smaller.												
The repeated measures ANOVA revealed that children in both EGA and EGB groups improved their jumping distance when compared to the children in the control group (p = 0.011).												

4.3 – Motor Proficiency

As for MP, the data are presented by eight subtests: fine motor precision, fine motor integration, manual dexterity, bilateral coordination, balance, speed and agility, coordination of the upper limbs, strength and total test score.

Table 5 displays the variation of fine motor precision, in the two subtests of the three groups studied in the different stages of evaluation.

Table 5
Mean values (standard deviation) and ANOVA results of repeated measures of the fine motor precision in EGA, EGB and the CG, during the three moments of evaluation.

	EGA			EGB			CG			ANOVA repeated measures		
Variables	**M0**	**M1**	**M2**	**M0**	**M1**	**M2**	**M0**	**M1**	**M2**	**I**	**G**	**I*G**
1.Mot.precis1	1.17 (0.75)	1.50 (0.83)	1.33 (0.51)	1.25 (0.88)	1.50 (0.75)	1.63 (0.51)	2.55 (0.52)	2.55 (0.52)	2.09 (0.53)	0.204	0.001	**0.029***
2.Mot.precis 2	2.67 (2.65)	2.50 (1.87)	2.50 (1.04)	1.38 (1.50)	2.62 (2.50)	2.38 (1.40)	4.55 (1.63)	5.18 (1.72)	4.18 (1.77)	0.211	0.006	0.212
3.Mot.inte1	3.67 (2.87)	4.67 (1.50)	4.17 (1.60)	3.38 (2.87)	3.88 (2.94)	4.13 (2.16)	5.00 (0.63)	5.18 (0.75)	5.36 (0.67)	0.072	0.216	0.581
4.Mot.inte2	1.83 (2.22)	1.83 (2.22)	1.50 (2.34)	0.87 (1.64)	1.13 (1.64)	3.38 (1.59)	4.00 (1.18)	3.18 (1.53)	3.73 (0.78)	0.046	0.015	**0.001***
5.Man.Dext	2.00 (1.26)	2.67 (1.21)	3.00 (1.09)	1.38 (0.74)	2.13 (1.12)	3.13 (1.12)	3.36 (1.50)	3.55 (1.75)	4.00 (1.34)	0.001	0.029	0.369
6.Bila.Coord1	1.50 (1.97)	2.00 (1.67)	2.50 (1.64)	0.63 (0.91)	1.50 (1.69)	2.87 (1.45)	1.82 (1.60)	1.55 (1.50)	2.00 (1.09)	0.004	0.891	0.102
7.Bila.Coord2	0.00 (0.00)	0.67 (1.21)	1.50 (1.37)	0.13 (0.35)	0.25 (0.46)	1.13 (1.35)	1.55 (1.29)	0.91 (1.04)	1.64 (0.92)	0.001	0.095	0.081
8.Balan	1.83 (0.75)	2.00 (1.09)	3.83 (1.32)	0.75 (1.03)	2.38 (1.40)	3.88 (0.35)	2.09 (1.22)	2.45 (1.12)	2.45 (1.36)	0.000	0.859	**0.003***
9.Agil.Spe	1.33 (1.75)	1.83 (1.72)	3.33 (2.25)	0.38 (0.51)	0.75 (0.70)	1.87 (1.80)	1.55 (1.12)	1.91 (1.04)	1.91 (1.13)	0.000	0.194	0.076
10.Coord.UL1	1.83 (2.48)	2.50 (1.97)	3.17 (2.22)	0.38 (0.74)	0.75 (1.16)	0.75 (1.03)	0.27 (0.46)	0.55 (1.03)	0.73 (1.48)	0.005	0.012	0.557
11.Coord.UL2	1.50 (1.76)	2.33 (2.25)	3.67 (3.01)	0.25 (0.70)	0.50 (0.75)	1.13 (1.72)	1.00 (1.18)	1.36 (1.20)	1.73 (1.42)	0.000	0.079	0.188
12.Strength	2.00 (2.19)	1.83 (2.04)	4.67 (2.16)	0.00 (0.00)	0.50 (1.06)	0.50 (0.92)	0.55 (1.21)	0.36 (0.80)	0.55 (0.82)	0.000	0.001	**0.000***
Total	21.33 (17.68)	26.33 (16.90)	35.17 (17.74)	10.75 (8.36)	17.88 (12.49)	26.50 (12.18)	28.27 (10.00)	28.73 (9.29)	30.27 (7.55)	0.000	0.151	**0.001***

V – variables; EGA – Experimental Group A; EGB – Experimental Group B; CG – Control Group; I – Intervention; G – Group; I*G – Group and intervention; T1 – Baseline; T2 - a half way through the intervention; T3 – after the intervention.

Fine motor precision, there were differences in the two subtests children in the EGB showed significant improvements (p = 0.029) in colouring a star across the three moments of assessment. On the other hand, the subtest of drawing a line through a path did not show significant improvements for both all three groups.

Table 6 reports the mean values and variance of the fine motor integration. The two subtests of this variable revealed different values. Regarding the item "copy two circles" called Mot.inte1 in the table, did not show any significant changes. However, in general, the mean values demonstrated improvements in the three study groups during the intervention.

The item that consisted of copying two inverted squares showed significant improvements after the intervention program. The mean values revealed major improvements for children in EGB and a smaller regression in the other two groups.

With regards to manual dexterity, no significant changes were recorded for all three group (p = 0.369). However, the mean values showed improvements, displaying more expressiveness in EGA and EGB.

The two items that make up the lateral coordination did not present any significant changes. The mean values improved in both EGA and EGB. Moreover, the CG reduces the mean values from M0 to M1.

Balance showed improvements in the mean values presented, with great expressiveness in EGA and EGB. The CG noted slight improvements from the first to the second moment, and remained that way until the end of the program.

As a result of the intervention program, this variable recorded significant improvements (p = 0.003).

Through the intervention program, improvements were recorded in speed and agility in EGA and EGB. The CG recorded minor improvements from M0 to M1 and remained that way until the end of the program. No significant improvements were recorded.

The two items reflecting coordination of the upper limbs registered improvements in all the stages of evaluation and in all of the groups. Similar to what happened to other variables, EGA and EGB revealed more expressive improvements. However, there were no significant improvements.

After the intervention program, significant improvements were recorded (p = 0.000) in strength level.

The overall result of the BOT-2 evolved consistently and increasingly from M0 to M2, in the three groups studied. However, the CG showed a slight increase (starting at 28.27 and reaching an average of 30.27 at the end). EGA rose from 21:33 to 35.17 and EGB recorded further progress showing mean values of 10.75 before the intervention, and 26.50 at the end of the intervention program.

Significant changes resulted from the intervention (p = 0.001) in the MP.

In general, it was found that EGB presented lower mean values than the other groups in the majority of the variables that constitute the MP test. Compared to the experimental groups, the CG was the one that showed the highest mean values in all variables, except for the coordination of the upper limbs.

All of the parameters exhibited noted improvements, more clearly those relating to EGA and EGB. On the positive side, manual dexterity, bilateral coordination, balance, speed and agility, coordination of the lower limbs and motor proficiency recorded improvements throughout the intervention program, in the two experimental groups. It should be noted that EGA did not show evident progress in motor precision nor in fine motor integration.

Discussion

5.1.1 - Body mass index

One of the objectives of this intervention was to assess the BMI changes of the participants. The findings of the study suggested that the intervention did not lead to any significant changes in the BMI (Table 3). These results are consistent with Pan (2011) findings that a group of children with ASD displayed no significant improvements in BMI after a water program intervention. The fact that the trampoline-based intervention did not result any changes in the BMI may be related to the frequency and duration of the program (45 minutes, 1 time per week), as well as the absence of any food control. The World Health Organization and the American College of Sport Medicine recommend that adults should consider 150–250 minutes of activity per week in order for significant reduction on body fat loss may help explain no significant BMI change in this study (Donnelly, Blair, Jakicic, Manore, Rankin and Smith, 2009).

However, the BMI results are contradictory to Pitetti, Rendoff, Grover and Beets (2007), who observed a decrease in BMI after 9 months of walking (30 minutes, 3 times a week). In addition, Quadros, Bruno Maurer and Piccoli (2014) state that regular physical activity contributes significantly to the reduction of cardiovascular risk, as well as to the decrease in waist circumference.

Thus, for the intervention to have an effect on BMI, three training sessions per week with a duration of 50 minutes per session are recommended for future research on BMI.

5.1.2 – Muscle Strength of the lower limbs

Some children with ASD have smaller levels of lower limb muscle strength than typically developing children (Kern, Geier, Adams, Troutman, Davis, King, & Geier, 2011; Ming et al., 2007). Since muscle strength of the lower limbs is one of the trampoline training programs' capabilities, it would be expected that this variable would register significant changes after the implementation of the intervention programs. Therefore, and when comparing the three groups, the training program has proven to be effective, with significant changes due to the evolution of the control group.

In a similar study, and after a 12-week trampoline training program in children without disabilities, improvements in the MSLL were reported (Atilgan, 2013).

In previous research with special populations (Eek, Tranberg, Zugner, Alkema & Beckung, 2008; Scholtes, Becher, Comuth, Dekkers Dijk & Dallmeijer, 2010), an increase in the MSLL was reported after the implementation of a strength training program that included jumps, which is comparable to the trampoline training programs implemented.

In the present study, although participants were not specifically subjected to a strength training program, the results obtained also showed a significant increase in the MSLL.

Thus, these results allow us to understand the effectiveness of the implementation of trampoline training programs in the strength of the lower limbs. In our view, these results may be related to the contents that made up the trampoline program, as they required all children to perform various types of jumps and, consequently, greater demands from the lower limbs.

Thus, the inclusion of the trampoline in physical activity programs in children with ASD is demonstrated as an effective mean of developing MSLL.

5.1.3 – Motor proficiency

In children, motor proficiency is positively correlated with physical activity and correlates negatively with sedentary activity (Wrotniak et al., 2006).

The data presented in this study showed significant improvements in motor proficiency after the intervention program. The present finding indicates that trampoline training contributes to the improvement of motor proficiency of children with ASD and is positively associated with enhanced balance, strength and fine motor integration. Previous studies demonstrated that balance, speed and agility, extremity muscle strength, flexibility and cardiorespiratory endurance of children with ASD has been improved with various interventions programs such as based on swimming (Yilmaz, Yanarda, Birkan, & Bumin, 2004) or postural control training (Cheldavi, Shakerian, Shetab Boshehri, & Zarghami, 2014).

Given the review of the literature conducted, no studies were available to present comparable results since no other interventions with trampolines in children with ASD were found. However, the results are in agreement with recent studies reporting an improved balance ability and motor performance of participants with intellectual disabilities (Giagazoglou et al., 2013), with developmental coordination disorder (Giagazoglou et al. 2015) and of elderly participants (Aragao et al., 2011, Oliveira, Silva, Dascal & Teixeira, 2014), after applying a training intervention with trampoline.

Conclusions

In general, it seems to be possible to demonstrate the potential of trampoline training programs, which have contributed significantly to the improvement of motor proficiency and jumping distance in children with ASD.

Since these children have problems in keeping their balance (Vernazza-Martin et al., 2005), and there is an urgent need to develop and implement new intervention programs based on the principles of movement and motor learning for children with ASD (Bhat, Landa, & Galloway, 2011), trampoline training seems to be an excellent proposal in tackling these problems. Apart from having a strong component of entertainment, which according to literature, is associated to the motor skills of a child with ASD, it also improves motor performance (Fournier et al., 2010). In this regard, the proposed training programs seem to be an excellent way of working with these individuals.

Hence, the major conclusion from this experimental work is the recommendation of exercises on trampolines by children with ASD, preferably more than once a week in order to obtain improvements in motor proficiency and muscle strength in the lower limbs.

Declarations

- Ethics approval and consent to participate

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced it outcome.

This manuscript represents results of original work that have not been published elsewhere.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all o fus.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. We further confirm that any aspect of the work covered in this manuscript that has involved human patients has been conducted with the ethical approval of all relevant bodies and that such approvals are acknowledged within the manuscript. All authors acknowledge ethical responsibility for the content of the manuscript and will accept the consequences of any ethical violation.

We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). She is responsible for communicating with the other author about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address which is accessible ccvl@ubi.pt.

- Consent for publication

All authors agree with the publication of the article.

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Carla Lourenço - ccvl@ubi.pt

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