Dynamic balance improvement in children with Autism Spectrum Disorder after an extracurricular Service-Learning Physical Education program

Abstract:

This study aimed to examine the acute changes in dynamic balance Postural Control experienced by children with Autism Spectrum Disorder (ASD) who undertook a 6-month extracurricular Service-Learning Physical Education (PE) program. The study used a quasi-experimental design with 23 participants divided into an experimental group and a control group. Limits of Stability protocol was used to measure the children's postural control. The results showed that the experimental group achieved statistically significant improvements. To conclude, this study provides substantial input about how extracurricular PE activities aimed at developing the general motor proficiency of ASD children can improve their dynamic balance.

Key words: dynamic balance, postural control, autism spectrum disorder, physical education, service-learning.

Lay summary: This study shows the improvements in dynamic balance in children with Autism Spectrum Disorder who participated in a Service-Learning Physical Education intervention program of 6 months of duration. These children improved qualitatively their time and maximal excursion point, as well as their capacity to control their direction. For this reason, the children who participated in this program improved their balance, which may prevent their risk of falls and improve their self-confidence when performing motor tasks and interacting with the environment.

1.Introduction

Autism Spectrum Disorder (ASD) refers to a range of multisystem neurodevelopmental disorders that affect people from early childhood. The prevalence of individuals with ASD has increased substantially in recent decades (Hamm & Yun, 2019). In fact, it seems to affect up to 2,5% of the population (Xu et al., 2018). Among other issues, regarding social skills, individuals with ASD show a reduced capacity to interact and communicate and they usually present restricted interests and stereotypical and repetitive behaviors (APA 2013; Benson et al., 2019; Bo et al., 2019; Hamm & Yun, 2019). In addition, they present some difficulties at a motor level (Lim et al., 2019). For instance, they display low levels of motor coordination (Koegel et al., 2001), difficulty self-monitoring (Hughes et al., 1994) and reduced Postural Control (PC) in bipedal stance when compared to Typically Developing (TD) individuals (Fournier et al., 2010).

PC is a fundamental skill required to maintain postural orientation and equilibrium. It has an important role in an individual's adaptation to changing environmental demands, as well as in the performance of motor skills (Mache & Todd, 2016; Pavão et al., 2013); it is therefore an important skill to ensure quality of balance for all types of populations. However, children with ASD commonly report PC deficits (Lidstone et al., 2020). In fact, anomalous postural development is one of the earliest observable disruptions in ASD children (Dawson et al., 2018; Leezenbaum & Iverson, 2019) and these deficits persist throughout their development (Doumas et al., 2016; Goulème et al., 2017; Lim et al., 2019; Mache & Todd, 2016). Thus, it is important to promote PC development among ASD populations from an early age because it is an essential factor affecting prevention of the risk of falls, among other aspects.

Physical activity and children with Autism Spectrum Disorder

Physical activity (PA) provides an opportunity for ASD children to increase not only social skills (Kroeger et al., 2007; Weiss & Harris, 2001) but also motor skills (Bo et al., 2019; Lord et al., 2000). Unfortunately, this population usually has fewer possibilities to be involved in extracurricular activities or programs aimed at promoting PA (Benson et al., 2019; García-Pastor et al., 2019; Pan et al., 2011). Therefore, this lack of participation in sport and exercise may further impact their early childhood development in general (Bo et al., 2019), including having reduced opportunities to develop their PC and balance skills. In this regard, this population should be provided with sufficient opportunities to exercise. Nevertheless, effective interventions are required for the promotion of physical education (PE) in children, particularly in the case of ASD individuals because of their characteristics.

Several studies have examined the impact of specific intervention programs for ASD children that focus on promoting PA. For example, a recent meta-analysis concluded that a number of positive effects can be perceived for children with ASD who were exposed to sport programs or PA interventions (Healy et al., 2018). The effects of such proposals include an improvement of both motor and social skills (Healy et al., 2018; Sowa & Meulenbroek, 2012; Yang et al., 2015). Thus, participation in sports and exercise programs may have a positive impact on ASD individuals' quality of life (Benson et al., 2019).

Some of the literature has previously examined PC outcomes of ASD children after a PA program. For example, Sarabzadeh et al. (2019) and Kim et al. (2016) carried out martial arts programs to uncover their effects on static and dynamic balance, and Cheldavi et al. (2014) prepared a special six-week-long balance training for ASD children. But to our knowledge, only one study has analyzed the effects on balance of a sports intervention that approached PE in a holistic way, specifically the SPARK program (Najafabadi et al., 2018). This 3-month

69 long program obtained positive results in static and dynamic balance; however, it was
70 managed by a number of specialized and expert staff, and carried out in a specific context.
71 In other countries, such as Spain, ASD children do not have this type of programs at their
72 disposal (López-Díaz et al., 2021; Urbaneja, 2015); therefore, there is a need to find
73 innovative ways to provide them with such opportunities, such as the program analyzed in
74 this study.

75 *Physical activity promotion through Service-Learning programs*

76 PA interventions can vary widely depending on their typology. The intervention program
77 whose effects were analyzed in this study was implemented as a Service-Learning (SL)
78 initiative carried out as part of a Physical Education Teacher Training (PETT) program. SL
79 is defined as a teaching methodology that seeks to develop academic and professional skills
80 in the students involved. In PETT programs, SL involves physical interaction and active
81 participation of both the PETT students and the people receiving the service, in this case
82 children with ASD (Carson & Raguse, 2014; Cervantes & Meaney, 2013). SL initiatives have
83 been found to be very useful for promoting PA and PE in a range of children with
84 developmental disorders (Capella-Peris et al., 2020; Chiva-Bartoll et al., 2020; Gil-Gómez
85 et al., 2015; Wilkinson et al., 2013). On the one hand, it seeks to develop the academic and
86 professional skills of the students providing the service. On the other hand, it helps to meet a
87 community need; in this case, providing ASD children with opportunities to engage in PA
88 and encourage their social interaction. Hence, sufficiently prepared students can lead SL
89 programs aimed at promoting PE among ASD children (Richards et al., 2012).

90 SL literature calls for research examining the effects that this pedagogical model may have
91 on the community (Capella et al., 2020; Chiva-Bartoll et al., 2021). Although different

studies show that SL programs in the field of PE may be instrumental to promote PA among children with developmental disorders, there are no studies focusing specifically on its effects on PC. Therefore, this article aspires to fill this gap, focusing specifically on children with ASD. This is relevant because this population usually presents an affection on PC and they have reduced opportunities to develop PC and balance skills. Therefore, it seems reasonable to examine whether a PE program through SL may have an impact on the PC of children with ASD.

Therefore, the aim of this study was to examine the acute changes in dynamic balance PC experienced by children with ASD who undertook a 6-month PE program through SL in Spain and to compare them with ASD children who did not participate in such a program. In this way, we will be able to determine whether a SL program is effective as previous specialized programs have demonstrated before in other contexts.

2.Methods

2.1.Hypotheses

(1) The experimental group will display a significant improvement in their dynamic balance PC after participating in the SL program.

(2) There will be significant differences in the pre-test and post-test measures of dynamic balance PC in favor of the experimental group.

2.2.Study design and participants

This study used a quasi-experimental design of two non-equivalent groups (experimental and control), with pre-test and post-test measures, in order to compare how participation in the intervention program affected the participating ASD children. This is a classic design that is

114 used to explore the causal relationship (effect) of the independent variable (PE program) on
115 the dependent variable (dynamic balance) (Yaremko et al., 2013). A total of 34 children with
116 ASD were recruited within a 100 km radius of the University where the research was
117 conducted in Castellón (Spain). The inclusion criteria consisted of: (1) a clinical diagnosis
118 (made by trained professionals) based on the diagnostic standards for ASD established in the
119 DSM-IV-TR or DSM-V-TR, (2) age between 5 and 16 years, (3) absence of any diagnosed
120 illnesses that hindered their performance of PA, (4) IQ ≥ 70, and (5) ability to follow
121 instructions. Of the 34 ASD children initially recruited, 29 met the criteria and were divided
122 into the experimental group (ASD_E) and the control group (ASD_C). The exclusion criteria
123 was based on the non-accomplishment of: (1) clinical diagnosis (made by trained
124 professionals based on the DSM-IV-TR or DSM-V-TR), (2) children younger than 4 or older
125 than 16 years old, (3) presence of any diagnosed illness that hindered their performance of
126 PA. Ultimately, 6 of the participants did not reach the end of the research. The final sample
127 considered in the study was 15 children in the experimental group (ASD_E: n=11 boys, n=4
128 girls; age: 10.43 ± 3 years old; body mass: 41.52 ± 14.65 kg; height: 137.47 ± 13.94 cm) and
129 8 in the control group (ASD_C: n=7 boys, n=1 girl; age: 10.13 ± 3.09 years old; body mass:
130 37.2 ± 16.0 kg; height: 140.13 ± 17.18 cm). Figure 1 shows the flow chart of participants.
131 The samples showed no significant differences (Table 1). These children were previously
132 diagnosed with ASD level I (70.4%), level II (18.5%) and level III (11.1%), according to the
133 DSM-IV-TR (APA, 2000) or DSM-V-TR (APA, 2013), thus being 67.9% fully included in
134 the school classrooms, 46.4% with hyperactivity, and 57.1% with impulsive behaviors. Any
135 of these traits prevented the children's involvement in the PA intervention program .

136 <<<Please, place Figure 1 near here>>>

137 <<<Please, place Table 1 near here>>>

138 *2.3.Instruments*

139 All tests were performed in a quiet room, near the university in which we performed the
140 intervention program. The Basic Balance Master system (NeuroCom, version 9.2.
141 Clackamas, OR, USA). Limits of Stability (LOS) protocol was used to measure the children's
142 dynamic postural stability before and after the intervention program, with six months of
143 difference among the measurements. It consisted of a portable force platform (46 cm x 46
144 cm x 5 cm) connected to a computer. A software program (NeuroCom Balance Manager®)
145 calculated the Velocity of the Center of Pressure (CoP) at a sampling rate of 100 Hz, based
146 on a simple inverted pendulum approximation using the sampled CoP data and the
147 participants' body height. Specifically, for the dynamic test, we obtained the results for
148 Reaction Time (RT; s), Mean Velocity of the CoP (MV; deg/s), Maximal Excursion (MXE,
149 %) and Directional Control (DCL; %) in the Antero-Posterior (AP) and Lateral (ML)
150 directions. After obtaining the data, they were entered into Microsoft Excel (Version 10 for
151 Windows, Microsoft) and then exported to SPSS V. 26 (SPSS Inc., Chicago IL, USA).

152 *2.4.Procedures*

153 *2.4.1.Balance test*

154 The dynamic test consisted of LOS and Rhythmic Weight Shift (RWS). During the LOS test,
155 participants had to reach the maximal distance from the initial point after standing for 8 s, in
156 eight directions: 1) forward, 2) forward-right, 3) right, 4) backward-right, 5) backward, 6)
157 backward-left, 7) left, 8) forward-left. Each test started at an initial point and participants had
158 to reach the specific points once the initialized recording test signal was given. The software

verified whether the procedures were performed correctly or had to be repeated if the children had started the test before the 8 s or had moved their foot from the platform. Once this test was completed, the participants performed the RWS test, in which they had to move their center of gravity in the AP and L planes at three velocities (slow, medium and fast). These rhythm indications were provided by the software, displaying a pictogram on the screen.

2.4.2..Program overview

ASD_E participated in an extracurricular PE program which was embedded within a SL Project within a PETT. The program followed some guidelines related to organization and the educational approach of the tasks that had been used in previous SL experiences (Richards et al., 2012; Vickerman & Coates, 2009). The sessions were managed by three trained coaches who had at least two years of experience in PE and by one special education teacher with expertise in developmental disorders, in particular children with ASD. Each PE session was also supported by at least 12 PETT students and supervised by an expert psychologist and the university professors involved in SL. Thanks to the SL methodology implemented, the children-to-staff ratio was between three and four, depending on each session and age group. Participants in the control group did not carry out extracurricular activities involving PA. This variable was controlled through previous interviews and subsequent reports from the families.

Regarding the PE program, sessions were one hour long and were carried out twice a week between November and May during the 2018/2019 academic year. The participants' attendance record showed a high degree of adherence to the sessions (91.2%). Each child with ASD received an invitation to take part in the PE sessions with a sibling or a friend, so that they felt more comfortable. Thus, between three and five TD children attended some of

182 the sessions. The program aimed to promote long-lasting and autonomous PA habits among
183 children with ASD, providing them with opportunities for future practice of healthy,
184 recreational and educational PA from a general motor proficiency perspective. Table 2
185 displays a general overview of the program and the sessions that were developed.

186 <<<Please, place Table 2 near here>>>

187

188 *2.6.Data analysis*

189 For the data processing, we first performed a descriptive analysis (M ± SD). After the
190 normality test, we performed the Mann-Whitney test for independent samples to verify the
191 non-significant differences of the sample characteristics and all the results of the pre
192 conditions, as well as the post conditions. As most parameters showed a normal distribution,
193 to compare the results before and after the intervention, we used Student's t-test for paired
194 samples for all parameters. For all the comparisons, the level of significance was set at $p <$
195 0.05.

196 *2.7.Ethical considerations*

197 This research was approved by the Ethics Committee of the University Jaume I of Castellón,
198 where the study was carried out. In addition, the participants' families signed written
199 informed consent to participate in the study. To counteract ethical issues, the families of the
200 participating children could decide which group to join (experimental or control). Therefore,
201 they all had the possibility to take part in the SL PE program. All the researchers met the
202 requirements established in the Declaration of Helsinki (1964).

203 **3.Results**

Limits of Stability (LOS)

Table 3 shows the improvements in the participants' results after the 6-month SL PE program. We observed that RTs decreased for all directions. The differences were significant in the forward ($p < 0.05$) and backward ($p < 0.05$) directions. For the other parameters, a tendency was observed. However, the results did not show significant differences.

<<<Please, place Table 3 near here>>>

Rhythmic Weight Shift (RWS)

The RWS results improved in all the conditions for the parameters of AP_DCL and AP_MV (Table 4). In the lateral trials, we observed that participants improved their slow and moderate velocities, therefore showing statistical differences in the Lateral_DCL post conditions between the experimental and control groups ($p < 0.05$). Slight improvements were also observed in the Lateral_MV parameter in the slow and moderate velocities.

<<<Please, place Table 4 near here>>>

4.Discussion

The purpose of this study was to examine the acute changes in dynamic balance PC experienced by ASD children who participated in a 6-month SL PE program. Several interesting findings were observed through the quasi-experimental design used in this research. Firstly, children belonging to the experimental group displayed better results in their dynamic balance PC RT and MV after participating in the SL program. These improvements were statistically significant for the forward_RT and backward_RT measures ($p < 0.05$). Secondly, we found significant differences in favor of the ASD_E in the lateral moderate_DCL PC category.

These results are encouraging because, in general, ASD children show poor PC due to a visual fixation deficit which could explain proprioceptive disorders with impacts on balance and PC, among other aspects (Paquet et al., 2019). In this regard, the findings of the present study are consistent with previous literature in the field. Several intervention programs examining balance outcomes on ASD children have been implemented previously. For example, a six-week Tai Chi Chuan training program appears to improve performance in dynamic and static balance tests after the intervention (Sarabzadeh et al., 2019). In a similar study, ASD children experienced improvements in PC following participation in an eight-week taekwondo intervention (Kim et al., 2016). However, these two programs focused specifically on martial arts, which are sports that tend to be closely linked to balance (Chan & Sze, 2013; Fong et al., 2012; Gatts, 2008; Pons Van Dijk et al., 2013). Also, a balance training program efficiently improved PC in ASD children (Cheldavi et al., 2014). In contrast, the SL program implemented in the present study followed a holistic approach to PE aimed at developing a range of motor and social skills. Thus, it was not only balance-focused, but it addressed the general motor proficiency of children with ASD. Despite this, according to the results of this study, the program may be effective in terms of PC improvement.

Our results can be compared to those obtained by Najafabadi et al. (2018). They carried out a 12-week PE program and their results showed that the balance of ASD children improved significantly. Specifically, they found that there was a significant difference between pre-test and post-test measures in dynamic balance. Our results are not so evident because only certain specific measures presented significant differences, although the majority of the measures showed a tendency to improve (Huseyin, 2019). Therefore, it seems that non-

balance-focused programs might also be useful for developing the dynamic balance of ASD children, including not only programs managed by a specialized team only, but also those carried out through SL and managed by PETT students who were guided by experts. This is relevant because it shows that SL may be effective not only for participant students, but also for the community participating in the program (Capella-Peris, et al., 2020), ASD children in this case.

The findings of the present study can also be compared with similar studies carried out in TD children. For example, a sports-based youth development program carried out for 18 weeks improved the participants' dynamic balance, among other aspects (Ho et al. 2017). Similarly, a 12-week conventional PA program showed improvements in dynamic balance for healthy Chilean adolescents (Bahamonde et al., 2019), and a 10-week recreational football training program found significant improvements in some outcomes of body balance (Wang et al., 2018). However, positive results are not always achieved. In this regard, a short-term resistance training program did not display a significant improvement in static or dynamic balance in the participating adolescents (Granacher et al., 2011). In addition, a systematic review on the effectiveness of exercise interventions in overweight/obese children showed that the results for balance were equivocal (Han et al., 2018). Therefore, it seems that results for balance development in TD children are uncertain, whereas programs for ASD children tend to achieve results that indicate a general improvement. This might suggest that, since ASD children show poor PC, this type of population may be more likely to improve their balance skills after a PE intervention. Therefore, the more opportunities they have to engage in PA programs, the better; and SL may be an adequate option to provide them with these options while being optimal for university students too.

In addition, it is important to highlight that PE programs have been proven to improve motor and social skills (Healy et al., 2018; Sowa & Meulenbroek, 2012; Yang et al., 2015) or communication and regulatory skills (Shanok et al., 2019) in individuals with ASD, despite the programs varying in content, outcomes and setting. Therefore, despite not being the focus of the present research, it is worth bearing in mind that the improvement of dynamic balance in this study may not be the only potential advantage for the participating ASD children (Sarabzadeh et al., 2019).

The findings of the present study are also relevant because severe peripheral vestibular dysfunction, such as that presented by many ASD children, may have a significant impact on quality of life (Van Hecke et al., 2019). In this regard, educational development may also be affected by vestibular dysfunction (Van Hecke et al., 2019), and bad postural stabilization may lead to avoidance behavior, lower self-esteem, anxiety (of movement), anger or frustration (Bart et al., 2009; Kreivinienė, 2016). Therefore, the improvement in PC displayed by participating ASD children may be beneficial to overcome all of these issues. Specific literature has reported that the practice of PA improves the children sensorial system (Cheldavi et al., 2014), especially the vestibular one (Valverde-Esteve et al., 2021), since they have the opportunity to challenge their gravity (Kern et al., 2007). Also, studies as the one by Peña et al. (2021), have recommend activities such as the exergames in the context of PA in order to improve the children vestibular PC stability.

These findings lead to the starting point, linked to the importance of providing ASD children with PE opportunities taking into account their specific features in order to induce effective changes in both sensory and motor systems, influencing present and future balance performance (Ricotti, 2011). In addition, from a general perspective, targeting motor skills

295 through PE programs could potentially remove barriers to independence and autonomy, since
296 motor difficulties in ASD have been linked to poorer independent-living skills (Ardalan et
297 al., 2019). In fact, Kuhlthau et al. (2018) demonstrated that behavioral, autism-related
298 features and physical conditions were associated with quality of life in individuals with ASD.
299 Therefore, maintaining an active and healthy lifestyle through regular exercise thanks to the
300 SL program may be a key element in improving the present and future quality of life in ASD
301 children (Sarabzadeh et al., 2019).

302 In turn, the literature shows that several SL programs have been carried out to provide ASD
303 populations with PE opportunities. In fact, a recent systematic review on SL through sport
304 reports that most of the groups receiving SL included people with functional diversity or
305 disabilities or children with special educational needs. However, these studies tend to focus
306 on the effects on the students rather than on the recipients of the service (Chiva-Bartoll et al.,
307 2019), which is what we have addressed here. Therefore, there was a lack of rigorous analysis
308 of the effects of SL on the population receiving the service (Carson & Raguse, 2014) and our
309 results have tried to contribute to an understanding of this niche.

310 The findings of this study should be interpreted with caution, since it is subject to some
311 limitations. Firstly, the number of participants was sufficient for the statistical analysis but
312 was too limited to be generalized in a categorical manner. Nevertheless, studies with this type
313 of population usually rely on data gathered with a similar sample size (Reinders et al., 2019).
314 In addition, the quasi-experimental design of the study attenuates this limitation. The
315 distribution between ASD_E and ASD_C was not random for two main reasons: on the one
316 hand, to counteract ethical issues related to denying participation in the program, and on the
317 other hand, to ensure the feasibility of the study, since control group participants might not

have been able to attend the program for reasons such as incompatibility with the schedule or distance from the activity, among others.

Regardless of these, this study has also some strengths such as the fact that it presented an in-depth, detailed, comprehensive, and objective examination of the variables analyzed. Anyway, future research could replicate this study with wider samples and in different contexts or focus on other specific aspects related to ASD motor skills and quality of life to further examine the possible impact of SL PE programs participation on these outcomes, also in the long term.

5.Conclusion

In its thorough desire to contribute to a better quality of life for children with ASD, this study analyzed the effectiveness of a 6-month extracurricular SL PE program regarding the development of dynamic balance. On the one hand, ASD_E children showed improvements in their dynamic balance PC for the forward_RT, backward_RT, backward_MXE and forward_DCL parameters. On the other hand, they also showed statistically significant improvements in their lateral moderate_DCL PC. It can therefore be concluded that, according to the results obtained, motor skills training based on a holistic and comprehensive PE approach seems to be helpful for reducing PC limitations in terms of dynamic balance. Thus, since this type of programs could be transferred to the daily life of children with ASD in many parts of the world, the outcomes of this study will aid teachers, clinicians and researchers when developing interventions and tests for children with ASD. Finally, a differential trait to highlight in this study lies in the support of the SL methodology when applying the extracurricular PE intervention program. This approach not only enables and facilitates the adequate implementation of the PE sessions, for example in terms of ratio

between children with ASD and educational staff, but also helps future PE teachers to acquire inclusive teaching skills in real contexts (Chiva-Bartoll et al., 2020).

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