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The Remedial Values of Adaptive Ball Types for Children with Autism Spectrum Disorders

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ABSTRACT
Previous studies in the area of motor impairments in children with autism spectrum disorders (ASDs) have warranted an urgent need to review interventions that support fundamental movement skills (FMS). This paper intends to investigate the effectiveness of adaptive ball types used within Physical Education (PE) on the object control proficiency (a subgroup of FMS), in children with ASDs. Following pilot work, 12 children (aged 14.70 ± 2.70) performed four object control tasks (throwing, catching, kicking and soccer style dribbling), using three different ball types (the Developmental Ball, an underweight ball and a control ball). A repeated measures ANOVA was run to statically analyse performance scores. The ANOVA indicated that the type of ball used (f(2,22) 22.798, p<0.001), activity undertaken (f(3,33)= 12.377, p<0.01) and the interaction between the two (f(6,66)=-70.163, p<0.01) ultimately, had a significant effect on motor proficiency. Moreover, the Developmental Ball proved to be consistently beneficial across the object control skills, with post hoc t-tests showing strong significance against the underweight ball in kicking (t(11)=-3,031, p<0. 033) and soccer style dribbling (t(11)=-8.603, p<0.016). This paper concludes Skogstad's creation to be an invaluable blueprint for the development of fundamental object control skills, in children with ASDs.

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Introduction
In 2010, autism spectrum disorders (ASDs) were reported as the most common paediatric diagnosis in the United States, with the Centres for Disease Control and Prevention (CDCP, 2010) estimating that about 1 in 110 children exhibit the disability [1, 2]. Given this wide-spread prevalence of the disorder, it is increasingly likely that Physical Education (PE) teachers and youth sport coaches will have pupils with ASDs in their lessons and sports teams [3]. ASDs are neurological disorder, which falls into three separate diagnostic subcategories: autism, pervasive developmental disorder–not otherwise specified (PDD-NOS), and Asperger syndrome [4]. Those with ASDs are associated by marked delays in: social interaction, communication as well as repetitive and restrictive behaviours, with Figure 1 exemplifying the conditions' complexities [3, 5, 6].

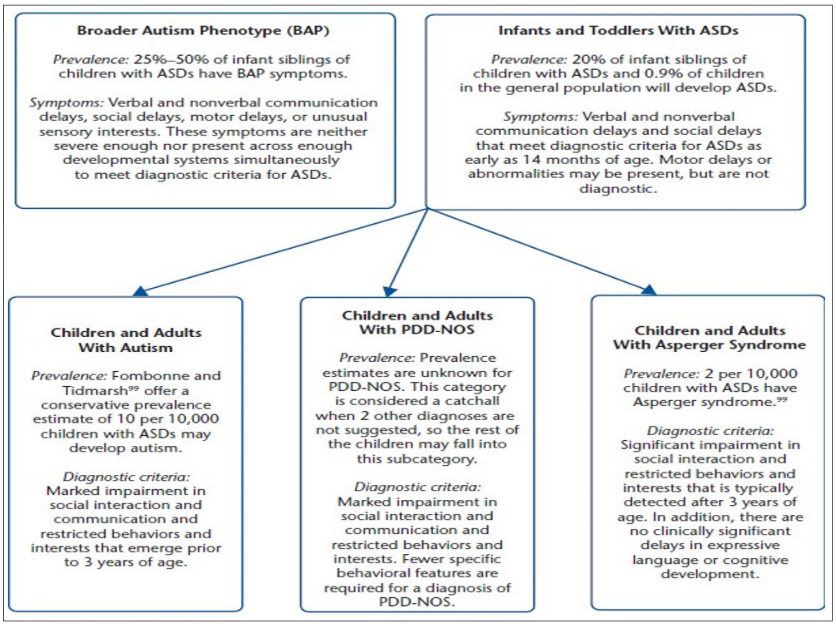

Figure 1: Illustrates the Key Social Impairments within the three Subcategories of ASDs, Bhat et al, (2011)

Whilst these are defining features of ASD, noticeably many children with the condition exhibit exceptional difficulties in performing daily tasks that require motor coordination, leading to the population being labelled as 'clumsy' and 'uncoordinated' [7, 8, 9]. A study by Ghaziuddin and Butler that used the Test of Gross Motor Development (TGMD), confirmed motor impairments in children with PDD-NOS. Moreover, Jansiewicz et al., research found further significance with motor impairments in children with autism and Asperger syndrome. Therefore, children with ASDs can then also be associated with motor impairments, often in the form of dyspraxia [8]. Research into the impact of motor impairments on children with ASDs however, is often overlooked and requires more empirical attention [10].

Goodway et al., propose that motor impairments may restrict opportunities to develop Fundamental Movement Skills (FMS) [11]. FMS can be categorised by the following skills: locomotor (such as; running, jumping and swimming) body management (such as; balancing, rolling and climbing) and object control (such as; throwing, catching and kicking). FMS are commonly regarded as essential 'building blocks' to physical, mental, and emotional development in childhood and adolescence as they make up such a large part of our lives [12, 13]. FMS however, do not naturally emerge as a result of age; they must be taught and practiced [11]. When these skills are not acquired, individuals lack the foundations for successful participation in physical activity [14]. Therefore, to avoid motor incompetency, PE intervention programmes that target FMS development among children with ASDs may (a) improve overall independence in daily functioning, (b) promote lifelong participation in health endorsing behaviours, and (c) encourage positive social engagement [15-17].

Inclusion within PE for children with motor impairments depends upon the teacher's ability to make necessary changes in their pedagogy, in particular the application of equipment to suit individual needs [18]. Bamett et al., found that object control proficiency, which requires the use of equipment, strongly influences successful participation within PE [19]. This equipment, in the case of children with motor impairments, often needs to be adapted [15, 20, 21]. Meaning that adaptive equipment used within PE may determine the successfulness of inclusive practice. However, a noted gap in research and the prevalence of FMS incompetency, questions the effectiveness of adapted equipment thus supporting the need for further academic review [22, 23].

Skogstad an adapted PE specialist for over 25 years, has observed pupils with motor impairments struggle with ball skills, highlighting a critical need for implementing an adaptive ball type that affords independent skill acquisition [24]. This led her to the creation of 'Developmental Ball' which aims to develop the following key object control skills: throwing, catching, kicking and soccer style dribbling. This innovative piece of equipment holds opposing characteristics to current adaptive balls types available on the market, however, the product lacks statistical rationality. Therefore; the following paper aims to compare the effectiveness of the following ball types: underweight and Developmental Ball, in relation to improving the following fundamental object control skill: throwing, catching, kicking and soccer style dribbling, for children with ASDs. Chapter 3 will explore what is already known about motor impairments in children with ASDs as well as questioning how ball types used within PE serve to intervene. Chapter 4 involves the methodology which will outline the research paradigm used to measure the difference between the ball types, with chapter 5 (results) presenting the findings. Finally, chapter 6 (discussion) will use the results gained to critically appraise the remedial effects of the ball types. Moreover, results may guide future research as well as providing a potential reference point for future interventions among this at-risk population.

Literature Review

This chapter explores relevant theoretical frameworks related motor impairments in children with autism spectrum disorders (ASDs). The outlay will acknowledge the benefits to physical activity and examine whether motor impairments associated with ASDs inhibit successful participation. This chapter will also critically appraise the effectiveness of adaptive ball types used within Physical Education (PE) as well as using Newell's (1986) person, task and environment model to introduce the Developmental Ball.

Much is known about the health and fitness benefits that result from increased physical activity (Table 1) [25]. One of the most logical arenas to promote physical activity for children is through Physical Education (PE) [26].

Functional Capacity

Increases maximal oxygen consumption and anaerobic threshold
Decreases heart rate

Reduced Risk of Medical Conditions

Reduces risk of developing: heart disease, diabetes, high blood pressure and obesity

Musculoskeletal

Helps maintain and enhance healthy bone density, muscles and joints Improves muscular strength and Fundamental Movement Skill (FMS)

Psychological

Promotes psychological well-being Improves self-image and self-efficacy

Table 1: Illustrates the Health and Fitness Benefits of Physical Activity [25]

Due to motor impairments, and the increased growth of ASD, attention has been directed towards the role of PE to encourage physical activity among this at-risk population [27-29]. The National Curriculum for Physical Education welcomes this notion, thus providing a platform that underpins the benefits of physical activity (Table 1) developing lifelong successful learners, confident individuals and responsible citizens [17]. Moreover, in relation to atypical social and communication characterises, research has shown PE to be an invaluable vehicle for empowering children with ASDs to seek out and interact with their peers [27, 30]. Therefore, to maximise overall physical, social, and emotional development across the lifespan, the significance of PE remains undisputed [31-33].

Given the importance of PE, educators must examine why activity levels among children with disabilities, specifically ASDs, are significantly lower than their typically developed peers [29, 34-36]. Consequently, inactivity impedes the benefits of health and fitness (Table 1) placing children with ASDs at risk of numerous health concerns, such as obesity [37, 38]. Goodway et al., indicates that inactivity may be accredited to motor impairments that make it challenging for PE teachers to create meaningful learning experiences. However, to truly include those with ASDs, PE teachers should not perceive these limitations as a barrier, but instead aspire to differentiate appropriately [39, 40]. Unfortunately, Vickerman and Coates study reported that 84% of PE teachers and 43% of final-year trainees within testing samples felt that Initial Teacher Training (ITT) had not prepared them practically to accommodate the needs of pupils with motor impairments [41]. Ultimately, inadequate knowledge and understanding leads to a 'Bag of Magic Tricks Syndrome' where teachers are placed in the deep end with survival being the daily goal, creating a mismatch between what is required and what is actually possible [42, 43]. Unfortunately, these negative variables often outweigh the positive, contributing to a decline in: participation, enthusiasm and ultimately the effectiveness of PE [44-46].

The notion that motor impairments restrict the development of Fundamental Movement Skills (FMS) means that pupils with ASDs are most likely to enter PE at a beginner's stage of learning [11, 47]. Therefore PE teachers must aim to develop FMS, which in turn, will support inclusion into lifelong health promoting behaviours. Bamett et al., found that object control proficiency strongly influences successful participation within physical activity. Adaptive ball types used within PE (beeper, nerf, geodesic mesh, cage, cloth and balloon balls) therefore, play an integral role in supporting the proficiency of key object control skills (throwing, catching, kicking and soccer style dribbling) and overall inclusion [19]. Typically, children with ASDs tend to demonstrate poor postural control, which affects locomotion and clear bodily boundaries; thus, contributing to the population being labelled as 'clumsy' and 'physically awkward' [6, 48, 49]. This has steered the selection of adaptive ball types used to include pupils with ASDs within PE, to be: underweight, oversize, soft material and sometimes even deflated, all in order to reduce the risk of injury [21].

Logically, the aforementioned characteristics of the ball types commonly used to accommodate children with motor impairments within PE impedes opportunities to improve and develop fundamental object control skills [50]. Specifically, in regards to children with ASDs, the underweight characteristics further tarnish their inability to shift between the 'bottom-up' and 'top-down' processing systems [51-53]. 'Bottom-up' processing refers to visual attention being drawn by the detection of noticeable stimuli in ones' peripheral vision, whereas a person's 'top-down' processing refers to the fixation on key visual stimuli in regards to the individual's current goals [52, 53]. For example; when performing ball skills in the gym, fixation on the ball itself (top-down) is essential. However, the underweight ball types tend to fly around the gym, creating highly distracting surroundings (bottom-up), which in turn, amplify processing difficulties. Consequently, the failure to shift between the two systems causes children with ASDs to fixate on either minor or irrelevant stimuli, producing significantly longer execution times and inappropriate responses [51].

In addition, Greenaway and Plaisted suggest that children with ASDs appear to demonstrate difficulties in processing rapidly moving stimuli [52]. The speed generated as a result of the underweight qualities causes a disappearance of a fixation point (top-down), making it increasingly difficult for children with ASDs to track the balls movement [54]. This supports Skogstads' observations of ASDs pupils spending the majority of their time in PE, chasing balls around the gym and playing fields, reflecting scenes of utter chaos [24]. Overall, underweight ball types can lead to highly stimulating environments, causing a bombardment of information to process and for the case of ASDs pupils; this often leads to states of over arousal [55, 56]. The 'Inverted-U' theory Yerkes and Dodson indicates that over arousal may further inhibit object control proficiency (Figure 2) as well as potentially triggering challenging behaviours such as screaming, hitting and biting, in an attempt to reduce the sensory overload [47, 57].

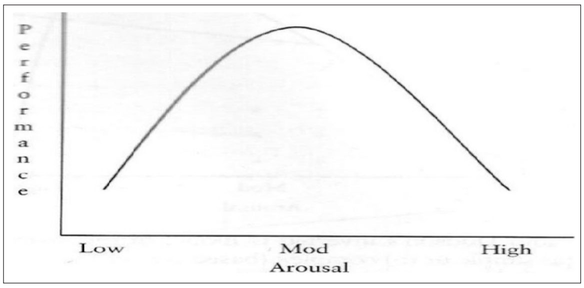

Figure 2: Illustrates Yerkes and Dodson's (1908) Inverted-U Model of the Arousal-Performance Interaction [47]

PE lessons should aim to maximise accessibility, safety and effectiveness, as well as being enjoyable [16]. Kozub suggests that the underweight adaptive ball types favour facilitation over the development of fundamental object control skills [43]. This highlights the educator's failure to evaluate or understand individual needs Fitzgerald, making it hard to identify any meaningful reason for children with ASDs to participate within PE. Teachers must remember that the learning experience belongs to the pupils and by 'wrapping the students up in cotton wool', so to speak, will not allow them to reap the full benefits of physical activity (Table 1). Nevertheless, it is important to note that research concerning ASDs and sensory processing is extremely contradictory [51-53]. Likewise, the soft grippy textures of underweight balls have shown to aid tactile deficits, supporting both: throwing and catching tasks therefore, the overall effectiveness of underweight ball types still remains in question [21].

Pope and Miller concluded that there is an urgent need to review the ways in which PE teachers can support the needs of ASDs pupils more effectively [58]. Aforementioned literature suggests that the underweight balls may expose pupils with ASDs to repeated experiences of failure. Wehmeyer et al., self-determination model, specifies that if a task is perceived as being too difficult, offering limited success, then a child with ASDs may lack motivation to sustain regular physical activity [59, 60]. Furthermore, shortfalls in fundamental object control skills are readily visible and can cause pupils with ASDs to withdraw from these activities out of fear of embarrassment and ridicule [14]. Bandura recommends that tasks which are: specific, realistic, and achievable, are most effective; increasing self-efficacy [61]. Therefore, adaptive ball types that support basic object control proficiency should in turn strengthen one's self beliefs increasing: motivation, enjoyment and the likelihood of lifelong participation in health promoting behaviours. Understanding and addressing the reasons why pupils with ASDs have poor object control proficiency is the first step to achieving this [14].

Bearing this in mind, PE teachers must examine whether they are asking the right questions in regards to whether their pedagogy provides beneficial learning experiences for all pupils. Newell's (1986) model (Figure 3) suggests that to truly include those with disabilities, teachers need to obtain as much information about three aspects of the performance and learning situation, these are: (a) the person, (b) the task, and (c) the environment. This model brings awareness to a range of factors that may inhibit motor learning, as well as encouraging appropriate adaptation in pedagogy to respond to the strengths and needs of all pupils [62].

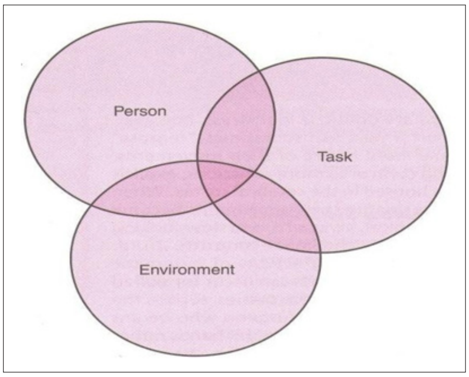

Figure 3: Illustrates Newell's (1986) Person, Task, Environment Model [13]

The most important aspect of this model is ultimately the 'person' performing the object control skills [13]. Every person brings their own unique set of innate characteristics that ultimately influence motor proficiency [63]. Children with ASD want to be included within PE, not just because of the health and fitness benefits (Table 1) but also the intrinsic rewards [64, 65]. Pupils with ASDs can perform object control skills more effectively if their learning experiences are more meaningful, realistic and motivating [14, 54]. Research has evidently found fundamental object control skills, for pupils with ASDs, to be susceptible to traits and characteristics (social, communication and motor impairments) that accompany the condition [11, 13, 67]. Understanding these features personalises learning in such a way it grants access to lifelong participation in physical activity [14, 23, 38]. Skogstad, created the Developmental Ball, with children who exhibit motor impairments as the target audience. Acknowledging a target audience allows them to enter tasks at a developmentally appropriate level [24].

The second situational component is that nature of the 'task' itself [13]. The Developmental Ball proposes to support independent object control proficiency in: throwing, catching, kicking and soccer style dribbling. These tasks contain sensory perceptual demands; such as, tracking the speed and direction of the ball [54]. Skogstad recognised that these demands, especially for children with ASDs, were dramatically increased when underweight balls were utilized [24]. Therefore, Developmental Balls designed for the ASDs programme were created with a balance system, involving specifically 10 ounces of sand. This weighted technology affords slow motion practice. The idea is that the pupils will be able to execute the same generalised motor programmes required to produce the task at normal speeds, however, the weight of the ball will allow performances to be slowed down. Schmidt and Wrisberg, suggests that this type of practice can be useful for pupils who are at the beginning stages of learning. This is because practicing tasks in slow motion affords time to track the ball's movement more effectively, which in turn, reduces errors and promotes appropriate movement patterns or schemas [13]. Therefore, the Developmental Balls weighted technology may facilitate positive movement patterns, allowing further opportunities for children with ASDs to independently develop fundamental object control skills (throwing, catching, kicking and soccer style dribbling) within predictable environments.

The third situational component is the performance 'environment,' which in the case of the Developmental Ball is in a typical PE situation (gym or playing fields). Judge, Floyd and Jeffs found that weighted products reduce over stimulating environments which may afford time for visual stimuli to be processed effectively, allowing actions to be planned and executed successfully [52, 53, 76]. Moreover, the weight of this ball provides positive proprioceptive feedback to the learner supporting awareness of bodily boundaries [24]. This places pupils with ASDs in a performance environment that affords levels of optimal arousal (Figure 2) deriving true object control proficiency as well as setting an appropriate platform for development [13]. As object control proficiency is acquired, motivation to participate in PE should also increase [14].

Skogstad, has evidently considered Newell's, (1986), model (Figure 3) in the implementation stages of the Developmental Ball which in turn proposes to provide opportunities for this at-risk population to gain full access and entitlement to the NCPE and lifelong health promoting behaviours [24]. Literature suggests that the Developmental Ball should be more beneficial for facilitating object control proficiency than the underweight ball, however, there is no statistical evidence to support this notion. Therefore, the null hypothesis for this paper states that there will be no differences between the ball types (underweight ball, Developmental Ball and control ball) across the following object control skills; throwing catching, kicking and soccer style dribbling. Furthermore, Dewey et al, and Bhat et al., suggests that the majority of the motor impairments observed in children with ASDs can be reflected across a range of disabilities. Therefore, findings collated from this paper may also be accountable for children with disabilities that contribute towards poor motor performance.

Methodology

This paper aims to examine the effectiveness of adaptive ball types in relation to developing the following fundamental object control skill: throwing, catching, kicking and soccer style dribbling, in children with autism spectrum disorders (ASDs).

Fundamental Movement Skills (FMS) are commonly regarded as essential 'building blocks' to: (a) overall motor independence, (b) lifelong participation in physical activity, and (c) positive social engagement [15-17]. One specific category within FMS, which this paper focuses on, is object control skills. Unfortunately, these skills are often lacking in children with ASDs due to motor impairments [11]. Bamett et al., indicates that for pupils with these motor impairments the successfulness of inclusion within Physical Education (PE) is dependent upon object control proficiency [19]. Therefore, the selection of adaptive ball types used to accommodate this population must be an educated choice. Underweight balls are commonly used for supporting key object control skills, when including pupils with ASD, into PE [21]. Past literature (chapter three) questions the effectiveness of the underweight balls for object skill proficiency as well as their effect on self-efficacy [54]. However, the overall effectiveness of the ball still remains in question [52]. Skogstad created the 'Developmental Ball,' which holds opposing characteristics to the underweight ball and aims to afford more opportunities for success in both; practising and developing fundamental object control skills (throwing, catching, kicking and soccer style dribbling) [24]. Therefore, this paper intends to statistically analyse the differences between the two ball types (which are the: underweight and Developmental Ball) within four activities (which are: throwing, catching, kicking and soccer style dribbling) for children with ASDs. The findings intend to provide a reliable reference point that enables both teachers and coaches to make educated choices when selecting appropriate ball types, which in turn promotes overall inclusion within PE and physical activity for children with ASDs.

The choice of ball types used for testing procedures had to reflect the aim of this research paper [67]. The underweight ball chosen was a 'Franklin Grip-Rite 500 rubber Ball,' acquired from an adaptive equipment catalogue and is typically used to support ball skills for children with motor impairments [68]. The Developmental Ball (10 ounces of sand) implemented specifically for children with ASDs, was acquired directly from the creator of the ball Pam Skogstad. Both the underweight ball and Developmental Ball were regulation size (8-inch diameter, size 5). In addition, a synthetic leather regulation size soccer ball, commonly used to support ball skills within mainstream settings was added as a control [21]. This took away the possible effects of extraneous variables (atypical weighting of the ball) so that the participants true object control performance could be measured and compared [69].

A widely used assessment of FMS is the Test of Gross Motor Development (TGMD-2) [70]. The reason why this paper did not template the TGMD-2 to the letter was because the following object control skills: underarm throwing and soccer style dribbling were not acknowledged. Therefore, in order for the research question to be answered, the method had to be adapted. Armour and Macdonald, suggests that for procedures to be valid and reliable measures of FMS performance, tests must measure what they are intending to measure, whilst upholding consistency and precision [67]. Therefore, after careful review, the testing procedures for 'catching' and 'kicking' were obtained from the TGMD-2. Unfortunately, the TGMD-2, throwing procedure used a one handed overarm technique, requiring hip and shoulder rotation [70]. This type of throw was inappropriate for this current paper, so for that reason, the required 'underarm throwing' procedure was obtained from the examiners' throwing guidelines in the catching condition of the TGMD-2. Finally, the 'soccer style dribbling' procedure used a simplified version of Russell et al., longitudinal study, which looked into the reliability and construct validity of soccer style dribbling tests [71]. These research methods provided general guidelines for administration, in relation to: equipment layout, testing procedures and performance criteria.

Performance scores (dependent variable) yielded from the aforementioned object control activities were susceptible to the independent variables (Developmental and underweight ball) and control (regulation soccer ball). This paper has opted to use a quantitative research paradigm; which requires these variables to be systematically measured, producing numerical data [69]. As the activities were taken from various studies, a new scoring system had to be implemented. For that reason, a rating scale was devised from a study by Hughes and Riley's, to quantify object control proficiency in a systematic way, based on deviations from good performance [72]. Houser, points out that rating scales help produce richer and more beneficial findings. Moreover, a Likert-type scale based on Williams et al., work, was used to measure environmental distractions [68]. Armour and Macdonald, suggest that working within natural environments helps increase ecological validity; however, reduces the ability to control the environment [67]. The value of this Likert-type scale is that it enabled the researcher to subjectively rate potential effects of the environment that may influence performance scores [68]. Structured observations were used to rate both the: performance scores and environmental distraction, Houser recommends direct observations helps gather more objective information from live situations [69]. In addition, Ohman and Quennerstedt mention that the movements observed within this study are far too complex to capture through first-hand observation alone; therefore, videotapes were used to further document, view and review the performances [73].

An order of administration for each skill was established. This was also based upon the work of Williams et al., which acknowledged methodological issues within the order of skills suggested in the TGMD-2 Examiner's Manual [68, 70]. Children were seen to exhibit confusion when moving from one skill to the next and therefore, a revised order was established. This revised order underpins the work of Gentile on skill acquisition, proposing that skills should appear in hierarchical order with regards to task complexity [74].

Furthermore, an order of testing conditions was also established, to avoid the learning effect. This was because the study used repeated measures, meaning the performance scores may become susceptible to the practice [69]. Armour and Macdonald, suggest that the most common method to counterbalance the learning effect is by implementing a crossover design [67].

After constructing the testing procedures, a pilot test was administered to detect errors and weaknesses in the method. This ensured that the testing procedures were appropriate and practical for the situation [67]. The TGMD-2 Examiner's Manual only permits two demonstrations, with instructions for each skill to be presented through a series of verbal commands. The pilot test found that the participants struggled with verbal instructions, leading to incorrect movements and ultimately poor performance scores [70]. The researcher realised that auditory instructions may be difficult for those with ASDs to process, therefore the way information was presented had to be amended [5, 6]. This led to more emphasis being placed on the visual demonstrations prior to testing. Testing only commenced when the participant truly understood what was required of them (using a thumbs up, thumbs down method), moreover, when necessary, additional demonstrations were permitted. In addition, if the participants continued to struggle, hand-over-hand guidance was provided during their practice trials [4]. Re-pilots concluded that this method facilitated understanding, leading to the researcher being completely satisfied with testing procedures.

Method

Participants

Demographic questionnaires were sent out to parents and guardians requesting information about the participants' disability as well as respectively reporting any issues with: throwing, catching, kicking and soccer style dribbling abilities. Sport participation, coordination and general 'clumsiness' were also noted. A Likert-type scale was used to assess these factors and participants were chosen based on the information gained from these questionnaires. In addition, to further confirm appropriate selection, considerable attention was given to the participants during sports sessions and spontaneous play, prior to testing. Participants were excluded from the study if they did not exhibit sufficient motor impairments. They also had to meet the age requirements (11-19 years-old), which reflects the years of secondary education.

The testing sample involved 12 participants, including; two 11 year-olds (one male, one female); one 12 year-old (male); two 13 year-olds (two males); one 14 year-old (female); three 16 year-olds (two males, one female); one 17 year-old (male); one 18 year-old (male) and one 19 year-old (male). Eight of the participants were diagnosed with autism, four were diagnosed with PDD-NOS and one was diagnosed with Asperger's disorder. Four participants within the sample exhibited the presence of one or more disorders in addition to ADSs, including: Attention Deficit with Hyperactivity Disorder (ADHD), Attention Deficit Disorder (ADD) and Developmental Coordination Disorder (DCD).

Data Collection

Data collection took place at a residential summer camp, facilitating children who exhibit a range of physical and mental disabilities, located on Long Island, United States. A high percentage of children with ASDs attended the camp which was opportune for the research, thus, making this study a convenience sample [69]. Overall testing was spread across a three-month period (June 2012 through to August 2012). All research was conducted on the same sports field, to ensure testing environments remained constant; the grass was cut to the same level each week. To collect data, three tests involving: throwing, catching, kicking and soccer style dribbling, were administered over the course of week, using the different ball types for each condition. Each condition was separated by a minimum of one day with two researchers present at all times. One researcher demonstrated the object control skills and rated both the environmental distractions and performance scores, while the other videotaped the performance. Direct observations allowed the researcher to acknowledge first-hand, how the participants reacted to each ball type across the different activities. In addition, the videotapes were carefully reviewed to confirm initial scoring; adding further validity to the study. Participants were tested individually and testing took approximately 20 minutes. Researchers selected the best possible circumstances for testing and where necessary, appropriate breaks were provided to avoid fatigue and maintain attention.

Evidently, the experiment used a repeated measures design, which allowed the researcher to evaluate change within the same group of participants across the three ball types; this method also helped remove the issue of individual differences [75]. However, because repeated measures require the same participants to perform the same tests three times, any significant changes in performance could simply be accredited to the practice rather than the effect of the ball types. Therefore, a crossover design was implemented to counterbalance the learning effect [67]. The cross-over design illustrated below helps increase validity as the ball types will receive equal exposure to the learning effect, thus reducing its influence on performance.

Table 2: Illustrates the Crossover Design

N=12	Condition A	Condition B	Condition C
N1:	Developmental Ball	Underweight Ball	Control Ball
N2:	Underweight Ball	Control Ball	Developmental Ball
N3:	Control Ball	Developmental Ball	Underweight Ball

Testing Procedures

During the testing conditions, the general guidelines for administration, from various studies (Huijgen et al., 2010) were explicitly followed, illustrated in Figure 5 below [70]. Prior to testing, two demonstrations were administered; first with the researcher facing the participants and the other was performed facing the direction in which participants were asked to perform the skill. Additional demonstrations and feedback were provided by the researchers, when necessary, to help focus attention within the task, reducing confusion and inappropriate movements [4]. After adequate demonstrations were given and the participant was ready, testing commenced.

Table 3: Illustrates Testing Procedures as well as the Requirements of Good Performance

Skill	Participants Directions	Errors in Performance
Throwing	1. Stand opposite the researcher, 15 feet apart. 2. Throw the ball underarm with a slight arc. 3. Target between researcher's waist and shoulders.	1. Trajectory showing no arc. 2. Missing required target.
Catching	1. Stand opposite the researcher 15 feet apart. 2. Arms extended with elbows flexed and hands ready for ball contact. 3. Catch the ball with hands only.	1. Loss of control. 2. Ball controlled with an unauthorised body part.
Kicking	1. Start 20 feet away from the goal with the ball placed 10 feet closer. 2. Kick the ball 'hard' towards the goal (80cm high, 80cm deep and 100cm wide). 3. Target is the goal, posts equals off target.	1. Missing required target. 2. Lack of fluidity.
Soccer Style Dribbling	1. Start and finish lines 25 feet apart, with 5 cones placed in a straight line 5 feet apart. 2. Dribble the ball whilst maintaining control and avoiding all cones. 3. Tests stop once the ball has crossed the finish.	1. Loss of control (including if the performance becomes too slow). 2. Contacting a cone.

Rating Scales Procedure

The numerical data was quantified through structured observations of live performances and videotapes, allowing differences between the ball types and activities to be made [67]. Both methods of data collection facilitated careful review performance, thus turning observations into numerical data. Good performance was recognised when a participant scored a top mark of three. Deviation or errors in performance (figure 4) subtracted one point from the score for that task. This resulted in the following possible scores for each object control skill: three = good (no deviations), two = fair (one deviation), one = poor (two deviations), zero = (unable to perform task or more than two deviations).

In addition, differences among testing conditions and unforeseen circumstances lead to a wide variation in environments [69]. Even though the researchers selected the best possible circumstances to perform procedures, testing took place during camp sessions, therefore, in some cases, it was not possible to avoid distractions, such as; other campers or counsellors interrupting performance. Based upon Williams et al., four categories were formed on basis of potential distractions: (1) noise level (such as; noise related disturbances from surrounding areas); (2) general distractions (such as; counsellors watching); (3) temperature; and finally (4) state of the playing field (such as: long grass or wet surface) [68]. A Likert-type scale rated the distractions with one = definitely interfering and five = not interfering. Environmental distraction scores from each condition were summed to give a mean distraction score for each ball type.

Data Analysis

Once all the data was collected and coded numerically, the information was then entered into the 'Statistical Package for the Social Science' (SPSS; version 20) for further processing. Skewness and Kurtosis calculations indicated that the yielded data was parametric. Therefore, a repeated measures analysis of variance (ANOVA) was used so that the performance scores (dependent variable) could be measured and compared, determining 'differences' between the ball types (independent variables) across the four object control activities (throwing, catching, kicking and soccer style dribbling). The null hypothesis for this paper states that there will be no significance found. A level of significance refers to the p (probability) of accepting or rejecting this null hypothesis [69]. For this paper, $p =< 0.05$ meaning that if the data was found to be significant then the null hypothesis could be rejected [69]. Line graphs were used to represent the descriptive statistics, illustrating the means and standard deviation scores.

Follow up paired samples t-tests were run, in order to explain the differences between the ball types and the different activities. However, the issue with follow up tests is that by increasing the search for significance also increases the probability of finding differences. Therefore, the Bonferroni Correction was used as a safeguard against falsely giving the appearance of significance, increasing both the reliability and validity of the t-tests [69]. The correction involved the level of significance (p value) being multiplied by the number of tests being run, decreasing the likelihood of rejecting the null hypothesis.

Ethical Considerations

In order to ensure that the research operated ethically, the researcher submitted ethics forms for clearance from the University of Chichester's ethics board. This confirmed that the study will do no harm to those involved as well as being worthwhile [67]. Participants needed for this specific study are acknowledged as a vulnerable population; for this reason, permission had to be granted to recruit the testing sample. Parents and guardians were informed about all aspects of the study, through an information package sent out by post and email. This package highlighted that participation is voluntary and that they had the right to withdraw at any time [69]. If parents or guardians were willing for their child to take part in the research, then informed consent was required on arrival. In addition, approval for tests to go ahead was granted from the camp's director and board. Moreover, the anonymity of this vulnerable population was imperative [69]. Therefore, all videotapes and information regarding the research participants was strictly confidential and kept in a safe location [69]. Data protection was appropriately managed, throughout testing, in such a way that participants came to no harm.

Furthermore, during testing, the safety of the participants was also upheld. All participants were required to wear rubber soled shoes for testing procedures, thus minimising the chances of: slips, trips and or falls. Finally, due to the fact that the researcher already had a strong relationship with the participants, the readings of specific situations, in particular the readiness of the participants could be acknowledged to prevent triggering challenging behaviours.

Limitations

It is sometimes acceptable to make general statements about a population, based on statistical findings from research papers. However, when the sample size is small and one of convenience, the likelihood for generalising the results back to the population is severely limited [69]. Therefore, the statistical findings within this study should be treated with caution as 12 participants may not reflect the entire ASDs population [69].

Moreover, as previously stated in this chapter, the use of rating scales will be at the control of the researcher. However, issues arise when researchers interject their own biases and viewpoints when scoring [69]. Therefore, in an attempt to uphold authenticity and validity, the second researcher (a primary school teacher) who works alongside children with ASDs also viewed the videotapes to cross-reference the researcher's scores.

In summary, this chapter has described the quantitative paradigm in which this study operates within. Along the way, testing procedures and limitations have been acknowledged and justified. Chapter five will now attempt to analyse the yielded data using SPSS version 20 to identify any significance differences between the ball types (independent variables) across the four object control activities (throwing, catching, kicking and soccer style dribbling).

Results

The primary aim for this study was to examine whether the ball types (control, underweight and Developmental ball) affected performance across four fundamental object control skills (throwing, catching, kicking and dribbling), in children with ASDs.

ANOVA

Repeated measures ANOVA tests were run to provide statistical evidence for differences between examined the main effects for the ball types, activities and finally, the interactions between the two.

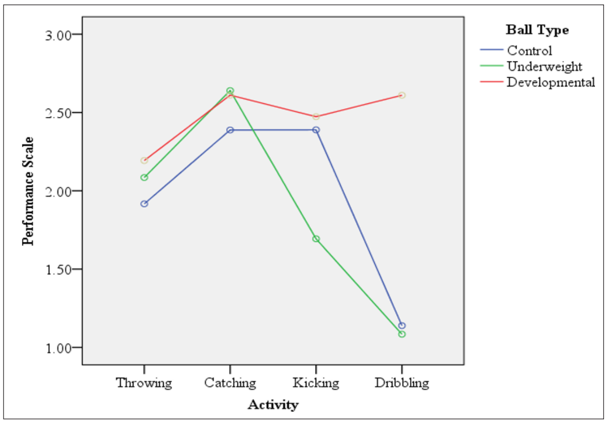

Figure 4: Illustrating Ball Type v Activity

The first ANOVA revealed the main effect for the ball types to be statistically significant ($f(2,22) = 22.798$, $p<0.001$). These findings suggest that the type of ball used significantly affects performance scores, with the Developmental ball displaying consistently higher means (2.47 + 0.56) when compared with the control (1.88 + 0.81) and the underweight ball types (1.96 + 0.80). The second ANOVA discovered the main effect for the activities to be statistically significant (f(3,33) = 12.377, p<0.01). Meaning that the activities undertaken also produced different performance scores, with catching, a less complicated activity displaying the most proficient performance scores (2.55 + 0.48) when compared with the kicking (2.07 + 0.67), throwing (2.19 + 0.62) and then, dribbling the most complex activity predictably displaying the lowest score (1.61 + 0.98). Finally, the third ANOVA proved the interaction between the ball types and the activities to be statistically significant (f(6,66) -70.163 p<0.01), indicating that the participants found different ball types easier to deal with for different activities. Therefore, follow up tests were run in order to explain the differences between the ball types and the different activities.

Post Hoc Tests

Bonferroni correction post hoc t-tests were run, to examine the significance between the ball types within each activity.

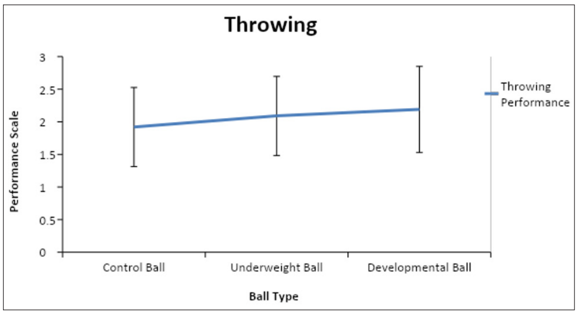

Figure 5: Illustrating Differences between Ball Types and Throwing Performances

All throwing conditions proved to be non-significant: control ball against the underweight ball ($t_{(11)}$ = -0.975, p<1.05), control ball against the Developmental ball ($t_{(11)}$ = -1.436, p<0.537), and the underweight ball against the Development ball ($t_{(11)}$ = -0.524, p<1.833). These findings show that the ball type had no significant effect on the participants' throwing performance. However, the means revealed that the Developmental ball produced highest scores (2.19 $\pm$ 0.66) when compared to the underweight ball (2.09 $\pm$ 0.61) and the control ball, which displayed the lowest scores (1.96 $\pm$ 0.61).

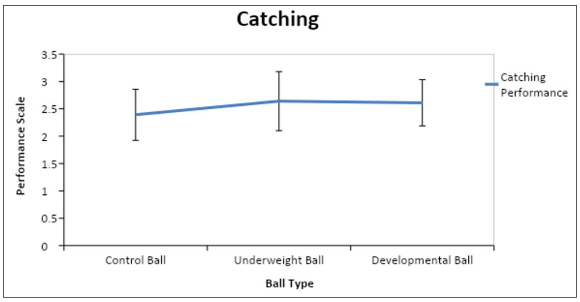

Figure 6: Illustrating Differences between Ball Types and Catching Performances

The catching condition showed some significant difference between the control and Developmental ball types (t(11) = -2.973 p<0.039), with the Developmental ball (2.61 + 0.42) showing higher performance scores when compared to the control ball (2.38 + 0.47). These findings indicate that the Developmental ball is more beneficial for catching performances than the control ball. Interestingly though, the underweight ball showed the highest mean score (2.64 + 0.54) yet, showed no significance when compared to the; control (t(11) = -1.403 p<0.564) and the Development ball types (t(11) = 0.202 p<2.532).

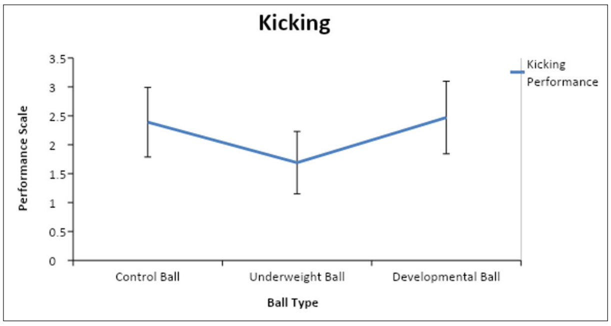

Figure 7: Illustrating Differences between Ball Types and Kicking Performances

The kicking condition showed some significance for both the control ($t_{(11)}$ = 3.069 p<0.033) and Developmental ball types ($t_{(11)}$ = -3,031 p<0. 033), when compared to the underweight ball. Moreover, the mean scores indicated that both the Developmental (2.47 $\pm$ 0.63) and the control ball types (2.39 $\pm$ 0.60) produced significantly higher performance scores than the underweight ball (1.69 $\pm$ 0.59). These findings show that when the participants used the underweight ball their kicking performance deteriorated. Furthermore, there were no significant changes in performance when the control ball was compared against the Developmental ball ($t_{(11)}$ = -3.031 p<0.33).

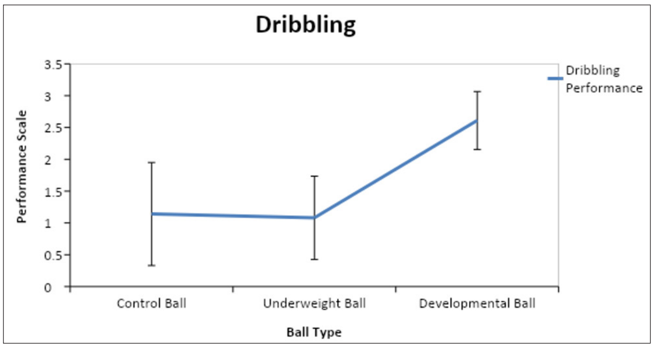

Figure 8: Illustrating Differences between Ball Types and Dribbling Performances

The dribbling condition showed overwhelming significance for the Developmental ball, when compared to both the underweight ($t_{(11)}$ = -8.603 p<0.016), and the control ball types ($t_{(11)}$ = -7.541 p<0.016). Figure 8, clearly indicates that the Developmental ball (2.61 $\pm$ 0.45) significantly yielded higher performance scores when compare to both the control (1.14 $\pm$ 0.81) the underweight ball types (1.08 $\pm$ 0.65). These findings show overwhelming evidence that the Developmental ball consistently improved the participants dribbling performances. Furthermore, the control and underweight ball comparison showed no significant difference in performance scores ($t_{(11)}$ = -3.031, p<0.33).

Gender Differences

An independent t-test was run to examine differences between the genders.

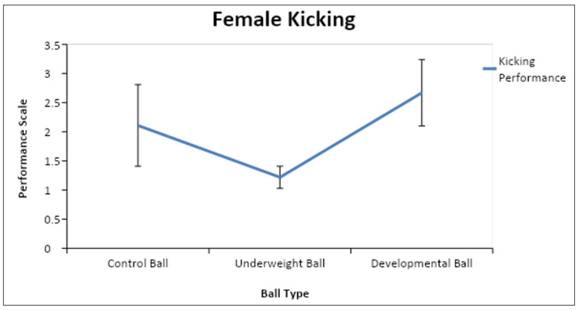

Figure 9: Illustrating Differences between Female Kicking Performances

The t-test found gender differences in kicking performance when using the underweight ball (t(612) = 3.308 p<0.013). Means scores indicated that boys performed better (1.85 + 0.52) when compared to the girls (1.22 + 0.19). Fascinatingly though, the standard deviation bars highlighted in Figure 9, indicate that the females (n=3) consistently struggled with the underweight ball, yet, with both the control (2.11 + 0.7) and Developmental ball types (2.67 + 0.57) they performed significantly better. These findings suggest that underweight ball, for females in particular, diminishes kicking performance.

Environmental Distraction

The distribution of environmental distraction scores, which used a Likert-type scale ranging from 1 to 5 (1 = definitely interfering and 5 = not interfering), were skewed towards the direction of 'non-distracting' for all ball types: underweight ball (4.56 + 0.30), Development ball (4.5 + 0.46) and the control ball (4.33 + 0.54). These findings show that in general the environments in which testing took place were not distracting.

In summary, the ANOVA proved that the ball type, activity and the interaction between the two were all significant, meaning that the type of ball used and the activity undertaken ultimately had an effect on the performance. Therefore, the Bonferroni follow-up t-tests were run to point out specifically which factors were significant. Moreover, the mean and standard deviation scores were examined to indicate whether these factors had a positive or negative effect on the participants' performance. T-tests showed the ball types to have no effect on throwing performance. T-test did however show some evidence that the Developmental ball was better for catching when compared to the control ball. Kicking performance showed the underweight ball to be inferior to both the control and Developmental ball types. Finally, dribbling showed the Developmental ball to be consistently superior to both the control and underweight ball types. Gender differences were acknowledged in kicking where males produced better performance scores however, mean and standard deviation showed females to be consistently poor with the underweight ball. The following chapter will attempt to critically appraise these findings in relation to the relevant literature.

Discussion

The purpose of this paper was to empirically examine the effectiveness of adaptive ball types (underweight and the Developmental Ball) across the four object control skills (throwing, catching, kicking and soccer style dribbling); in children with autism spectrum disorders (ASDs). Research has often overlooked the effectiveness of adaptive ball types on object control proficiency concluding an urgent need to review the ways in which Physical Education (PE) teachers can support pupil's with ASDS [14, 22, 23, 58]. As predicted, a repeated measures ANOVA established differences within the ball types across the object control tasks (f(6,66)=-70.163, p<0.01) allowing the null hypothesis to be rejected. These findings support Bamett et al., research, as the type of ball selected to accommodate pupils with ASDs significantly influences motor performance, which in turn, determines both: successful inclusion in PE and lifelong health promoting behaviours [19].

Post hoc t-tests were run in order to clarify which ball type proved to be most effective within each object control task. The strongest significance was established within the dribbling condition, where the Developmental Ball demonstrated overwhelming proficiency, when compared to both the control (t(11)=-7.541, p<0.016) and underweight ball types (t(11)=-8.603, p<0.016); supporting Skogstad's creation [24]. Testing procedures clearly demonstrated that the Developmental Ball's weighted technology facilitated slow motion practice, affording sufficient time to track the movement of the ball [13]. The Developmental Ball consistently produced more controlled, planned and precise movement patterns; which in turn, supported positive proprioceptive feedback [24, 76]. On the other hand, the underweight ball proved to be most detrimental to dribbling proficiency. This could be accredited to the underweight qualities generating rapid speeds; tarnishing sensory processing deficits [52]. However, it is noteworthy that comparisons between the control and underweight ball showed no significance (t(11)=-3.031, p<0.33) illustrating the importance of over weighted products. Therefore, the Developmental Ball should undisputedly, be utilised to support dribbling proficiency for pupils with ASDs.

Considering the kicking condition, participants again found the underweight ball to be significantly challenging when compared to both the control (t(11) = 3.069, p<0.033) and Developmental ball types (t(11) = -3,031, p<0. 033). Differences may have arisen due to the underweight qualities producing rapid and unpredictable movements (Todd et al., 2009). The fact the Developmental Ball proved to be significant in comparison to the underweight ball as well as generating the most efficient kicking performances, partially supports Skogstad's creation [24]. Observations from testing procedures noted the trajectory of the Developmental Ball to be more controlled, permitting appropriate movement patterns to be executed [13]. Despite this, the Developmental Ball showed no significance when compared to the control ball (t(11) = 3.031, p<0.33). This means, in relation to developing kicking performances within PE, the Developmental Ball would be an efficient selection; however, the control ball would be just as significant, whereas, the underweight ball will be detrimental. Moreover, the only difference between genders was found within the kicking condition.

The t-tests illustrated a substantial gap, favouring males, when using the underweight ball. These findings could be explained by Barnett, et al. (2008) work, who reported gender differences in kicking (throwing and catching) fuelling speculation that physiological differences limit female kicking ability. However, the standard deviation scores illustrated that females also struggled with the underweight ball, yet, with both the control (2.11 +0.7) and Developmental ball types (2.67 +0.57) they performed significantly better, contradicting Barnett, et al. (2010) work. PE teachers therefore, may find it useful to acknowledge that the underweight ball, especially for females, diminishes kicking performance. Butterfield et al., conclude that females, in particular, would benefit from interventions (such as, the Developmental Ball) that aim to develop fundamental object control skills [75].

'Catching' produced some interesting findings, with the underweight ball demonstrating the most proficient performance scores. Testing procedures showed the underweight ball's soft grippy textures, to facilitate secure grasps, enhancing catching capabilities [21]. T-tests however, found no significance when compared to both the control ($t(11)=-1.403$, $p<0.564$) and Developmental ball types ($t(11)=0.202$, $p<2.532$). Curiously, significance was found between the control and Developmental ball types ($t(11)=-2.973$, $p<0.039$), with the Developmental Ball proving to be more beneficial for catching performances. Observations found the Developmental Ball's weighted technology to act as a shock absorber, with the sand cementing the ball within the participants grasp. Whereas, the control ball, in some cases, tended to rebound out of the participants hands, resulting in the ball needing to be controlled by additional body parts, changing the dynamics of the skill itself [13].

Therefore, the underweight ball would appear to be an efficient selection for enhancing catching proficiency. However, the Developmental Ball will be just as significant; partially supporting Skogstad's creation [24]. PE teachers may find it useful to acknowledge when choosing between the two ball types, that potential catching errors may lead to underweight ball flying around the 'gym'. The 'chaos' created, could then present highly stimulating environments; which, in the case of pupils with ASDs, often leads to states of over arousal and ultimately deterioration in motor performance [55].

No significance was found within the throwing condition; however, performance scores did indicate that utilising the Developmental Ball enhances throwing proficiency. Nonetheless, observations indicated that the Developmental Ball's weighted technology in some cases inhibited throwing performances, with participants struggling to reach the required target. Understanding individual differences that may restrict throwing capacities will enable PE teachers to select the most developmentally appropriate ball type to enhance throwing proficiency (Novel, 1986). The Developmental Ball does come in reduced weights to accommodate these needs [24]. Furthermore, reasons for the throwing condition being the only skill that showed no significance may be attributed to the fact that it is an easier task, provoking fewer deviations observed in performance.

T-tests used to examine gender differences, only found significance within the kicking condition. These findings contradict the work of Barnett, et al. who suggested that differences should also have been expected within the catching and throwing conditions. The fact that no significance was found could be accredited to the sample being small and unbalanced ($n=9$ males, $n=3$ females) [69]. Therefore, the fact that any significance was found at all, only further exemplifies the detrimental effect in which the underweight ball conveys. In hindsight, the rating scales used to measure the participants' object control proficiency, may have inhibited and in some cases even facilitated the significant differences. For example, the qualities of movement were not measured alongside performance scores, meaning that participants could potentially score full marks for an action that was not necessarily correct. This occurred within the dribbling condition (strongest significance); where the Developmental Ball tended to cling to the participants feet, however, in some circumstances, dribbling performances became far too slow, essentially changing the dynamics of the skill itself. Therefore, one could argue that a limitation of the rating scales used, is that it could falsely accredit incorrect movement patterns as being positively significant.

In summary, the findings from this paper recommend the Developmental Ball for teaching: throwing, catching, kicking and soccer style dribbling to children with ASDs.

Even though the results may only partially support Skogstad's creation, the Developmental Ball reflects consistently high-performance scores across all object control skills; showing strong significance in both dribbling and kicking [24]. On the other hand, the underweight ball commonly used within PE to accommodate pupils with motor impairments has proved to be detrimental to both dribbling and kicking proficiency. Therefore, these findings suggest that the intervention of the Developmental Ball should be utilised within PE to support and develop ball skills, thus allowing pupils with ASDs to gain full participation in health promoting behaviours. Chapter seven will now revisit the research question, highlighting key limitations and future recommendations for the paper.

Conclusions

To the author's knowledge, this was one of the first studies that examined the effectiveness of adaptive ball types across fundamental object control skills, in children with autism spectrum disorders (ASDs). The findings of this paper are strongly recommended for Physical Education (PE) teachers who are required to acknowledge children with motor deficits and be willing and ready to rise to challenges in which they present [17]. Given the increasing numbers of children with ASDs, it is highly desirable for PE teachers to possess a specific ball type that facilitates the development of fundamental object control skills, such as: throwing, catching, kicking and soccer style dribbling. This paper has provided statistical evidence, proving the Developmental Ball to be most beneficial for supporting these skills when compared to the commonly used underweight ball types [78].

Despite this, there is a clear need to review the studies' inherent limitations. First, methodological issues regarding the testing sample being small and one of convenience, limits generalisation; meaning these findings can only be considered as preliminary [69]. Future research that aims to replicate this study will need to change key aspects of the sample method, to further support the research question. Firstly, by increasing the size as well as balancing the gender cohort so that the findings may reflect a larger population. Secondly, the study does not measure how object control proficiency varied across different subcategories of ASDs nor other disabilities that contribute to motor impairments. Therefore, future research should sample a range of disabilities and measure participants separately, so that individual differences can be acknowledged [69].

Previous chapters have highlighted how the rating scales used may have affected both the validity and reliability of testing procedures. The rating scales facilitated efficient data collection, based on deviation from good performance; however, they did not assess the quality of movements, resulting in some participants scoring full marks for incorrect actions.

Therefore, future research should be longitudinal, which in turn, will afford efficient time for researchers to measure the ball type's effectiveness on the quality of movement as well as deviations when performing fundamental object control skills. Furthermore, time constraints also meant that this study could not measure the ball type's long-term effects on other important characteristics, such as; prolonged sporting participation and self-efficacy. Therefore, longitudinal research is crucial to obtaining a better understanding of the Developmental Ball's true impact on children with ASDs.

The success of the Developmental Ball is clearly evident within the findings of this paper; however, it is acknowledged that the ball is still in its proto-type phase of development. Therefore, due to there being little to no significance within the throwing and catching conditions, re-modelling of the Developmental Ball could further enhance the effectiveness of Skogstad's creation [24]. Even though the underweight ball proved to be detrimental to both dribbling and kicking proficiency, its soft grippy qualities appeared to be advantageous with regard to securing sufficient grasps of the ball as well as minimalising the risk of injury [68]. Likewise, the control ball's padded outer layer also reduces elements of risk; whereas, one might argue that the Developmental Ball's weighted technology disregards these aspects. The author of this current paper therefore suggests rectification in a relatively simply way such that the outer layer of Developmental Ball to be replaced with the padding of the control ball; moreover, the surface of the ball to be covered with the grippy surface of the underweight ball, thus, enhancing the participants grasp and safety. Effective re-modelling of the Developmental Ball will enable PE teachers to select an appropriate ball type that is 'significantly' beneficial across the four fundamental object control skills.

The fact there has been little research into the effectiveness of adaptive equipment and that this current paper has shown that successfulness in object control proficiency is significantly dependent on the appropriate selection of adaptive ball types, opens numerous avenues of inquiry within the PE profession. Adaptive ball types only make up a small branch of equipment that support object control skills, therefore, future research clearly needs to be extended and directed towards the effectiveness of other adaptive equipment used to support pupils with motor impairments. Moreover, further research needs to examine the efficiency of both Initial Teacher Training (ITT) and Continued Professional Development (CPD) in regards to knowledge and understanding of resources available that support children with motor impairments. In the meantime, design limitations aside, this paper recommends the Developmental Ball to both teachers and coaches aspiring to develop fundamental object control skills for children with motor impairments, especially those with ASDs [77].

In summary, it is expected that even greater improvements in object control proficiency among children with ASDs is possible if future research uses this paper as a basis for the on-going refinement of the Developmental Ball towards its full potential. As our knowledge and understanding of the effectiveness of adaptive equipment increases, it is likely that interventions that aim to support children with ASDs become more widespread and common in practice thus, maximising overall physical, social, and emotional development across the lifespan [10]. The path to motor competency remains unknown for children with ASDs but by introducing tools such as the Developmental Ball we can provide a firm foundation from which to establish positive learning environments, enriched with opportunities for success, enjoyment, and entitlement to lifelong health promoting behaviours.

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