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Do we need norms of fitness for children with autistic spectrum condition?

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The increasingly sedentary habits of children, and rising obesity levels, are prompting concern for children's future health. Children with autistic spectrum condition (ASC) show a clear trend in this regard. Within school, an understanding of how an individual's fitness compares to age norms is important in order to design appropriate exercise programmes. This study, by Maurice Place, Kathleen Dickinson and Joanna Reynolds, all based at Northumbria University, assessed 100 children with ASC and learning difficulty, and found a wide variation in fitness levels as measured by the Eurofit tests. In addition the measure of cardio-pulmonary fitness ($VO_{2\ max}$) was generally poor. In boys, body mass index (BMI) showed only a modest correlation with this measure of cardio-pulmonary fitness, with the results for the girls not being significant. Using a variant of the established BMI calculation did not improve the correlation. To our knowledge this article offers the first set of published Eurofit test results for children with ASC and highlights the generally poor level of cardio-pulmonary fitness in this group of children.

Key words: **fitness, autism, cardio-pulmonary fitness, autistic spectrum disorder**

Background

In recent years there has been growing concern that children are becoming less physically active, and overall – although the trends in different countries vary to

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some degree (Moliner-Urdiales et al., 2010) – the general pattern is towards a decline in physical fitness in both boys and girls (Tomkinson, Léger, Olds & Cazorla, 2003). This, together with the increase in childhood obesity, has led to predictions that the physical health of this generation of children is at greater risk than previous generations, both now and in the future (Lloyd, Colley & Tremblay, 2010).

The relationship between fitness and health in children is now established, with physical fitness having been found to have an association with metabolic health (Ortega, Ruiz, Castillo & Sjostrom, 2008) and cardio-pulmonary fitness. In turn, the level of cardio-pulmonary fitness is strongly associated with decreases in blood pressure (Gaya et al., 2009) and an overall reduction in risk of cardiovascular disease (Soares-Miranda et al., 2011; Dencker et al., 2012).

It is a long-standing principle of health care to establish norms for physical and functional activity. These not only permit the results from a particular individual to be placed within the context of the general population, but also allow results that are associated with disease to be identified, and permit the pattern of results for specific groups to be tracked over time. In terms of physical fitness, work in this area has produced advice on appropriate minimum activity levels for both adults and children. The HELENA-CSS multi-centre, cross-sectional study performed in 10 European cities from nine countries (Moreno et al., 2008) provides information about physical exercise levels for children. Based on the findings from their large sample, this group recommends that the threshold of exercise for cardio-pulmonary fitness is at least 37 minutes per day of moderate exercise, or more than 19 minutes per day of vigorous physical activity in boys. For girls the recommended levels are 34 minutes per day of moderate exercise, or more than 12 minutes of vigorous activity per day (Martinez-Gomez et al., 2010).

One of the measures commonly used to assess the impact of exercise on cardio-pulmonary function is the $VO_{2\ max}$, which is an estimate of the maximum capacity of an individual's body to transport and use oxygen during incremental exercise. This measure has been found to reflect cardio-pulmonary status accurately (Shephard et al., 1968) and, in the case of children, it has been shown to be associated with a lowered risk of cardiovascular disease in both boys and girls (Dencker et al., 2012). Thus, ensuring that children achieve a level of physical activity that gives them optimal cardio-pulmonary fitness should be a key goal for physical education programmes. There are norms available which rate the cardio-pulmonary fitness of teenagers according to their $VO_{2\ max}$ scores (Léger &

Lambert, 1982; Heyward, 1998), but there are no reports as to how children with autistic spectrum condition (ASC) fare in this regard.

Unless there are structural anomalies, all children have the same cardio-pulmonary structure, and so presumably the norms for $VO_{2\ max}$ will remain appropriate for children with disabilities. However, what remains unclear is what the outcome of such assessments say about the fitness of children who have significant special needs. In addition, to our knowledge there are no published norms for fitness test results in children with ASC. In order to explore this issue further, as part of a larger study, an assessment was undertaken of the fitness levels of 100 children with ASC in the moderate to severe range of intellectual disability, who were being taught in specialised educational settings.

Method

Having obtained ethical approval from academic bodies, educational gate-keepers and parents, the study was carried out in one academic school year (September 2011 to June 2012).

Sample

The children attending the three schools that offered specific educational provision for children with ASC in one geographical area formed the study group. The children in these settings ranged in age from five to 15 years, and the families of all the children were approached to participate in the study. Following a process of informed consent, all parents consented for themselves and their children to take part and 100 were chosen at random to participate. The Statement of Special Educational Needs for all of the children indicated they needed to be taught in a setting specifically designed to education children with ASC, and they all had an IQ in the moderate/severe range of learning difficulty. None had any physical disorder or illness that would reduce their ability to participate in the fitness tests.

Background information was collected concerning family makeup, medical conditions, employment of parents and so on, providing additional variables to support the matching of intervention and control groups.

The demographic information and details of family makeup revealed that 85 were under the age of 12 years, and 79 were boys. All the children had moderate to severe learning difficulties, and 75 were living with both parents. Thirty-four were the only child in their family; in terms of parental employment, 16 came from families where both parents were working and 25 from families where both parents were unemployed.

Procedure

The physical fitness of the children was evaluated using elements of the Eurofit Physical Fitness Test Battery (Council of Europe, 1993), which is a set of nine physical fitness tests covering flexibility, speed, endurance and strength. The five elements of the test that were chosen for this study were the multistage progressive shuttle run test (known as the bleep test), the standing long jump test (known as the broad jump), the 10 x 5 metre shuttle run, the partial curl up test (known as sit-ups) and the sit and reach test, which assesses flexibility. This latter test uses a negative score so that poorer flexibility is represented by a larger negative score. These tests have been shown to have good reliability in typically developing children (Tsigilis, Douda & Tokmakidis, 2002) and adequate reliability in children with mild intellectual disability (MacDonncha, Watson, McSweeney & O'Donovan, 1999), and have been recommended as the optimum programme for assessment (Safrit & Wood, 1995). This is one of the first descriptions of its use with children who have moderate to severe intellectual disability.

One element in particular, the bleep test, has been shown to be a good measure of cardio-pulmonary function, and has been accepted as the standard measure by the National Coaching Foundation of Great Britain (1988). This test also has the advantage of published norms for typically developing children, and offers the opportunity to estimate the $VO_{2\ max}$ score from the results, using age as an influencing parameter (Léger & Lambert, 1982).

The testing was carried out within the scheduled time and venue for the children's regular PE classes, and was conducted using the procedure described in the standard protocols which accompany each of the tests. To help the children understand the test elements, visual modelling was used together with simplified instructions. The protocol instructs the children to continue with the test until they can go on no longer, and the schools' teaching staff were asked to give any additional instruction necessary to ensure the children understood the procedure. To familiarise the children with the test, trial runs of the tests were carried out on two successive weeks, with the actual testing being done some six weeks later.

All statistical analyses were conducted with SPSS version 21.0 (SPSS for Windows Inc., Chicago, IL, USA). Each data set was analysed by the Shapiro–Wilk Test (Shapiro & Wilk, 1965), and for any that proved to be non-parametric, their results are presented in appropriate format, with the parametric data sets' results being presented as means and standard deviations. The Kendall's rank correlation coefficient (Kendall's tau) was used in analysis of the correlation matrix because some of the elements were non-parametric data sets.

Results

The scores on the fitness tests were considered broadly by primary and secondary age groups, and gender (Tables 1 and 2). In general the boys' physical fitness scores tended to increase with age (except for the bleep test, which showed no meaningful change), with the broad jump (Mann–Whitney U test $z = 2.71$, $p < 0.05$) and sit-ups (Mann–Whitney U test $z = 2.61$, $p < 0.01$) reaching statistical significance. In terms of fitness for the girls, bleep test, broad jump and sit-ups showed better scores in the older age group, with the latter two being statistically significant (bleep test: Mann–Whitney U test $z = 1.83$, NS; broad jump: Mann Whitney U test $z = 1.99$, $p < 0.05$; sit-ups: Mann–Whitney U test $z = 2.86$, $p < 0.005$).

The fitness scores of the younger boys were slightly higher than those achieved by the girls, with the exception of the 10 x 5 metre run, but only the bleep test reached statistical significance (Mann–Whitney U test $z = 2.16$, $p < 0.05$). In the older age group boys generally had slightly higher scores than girls, but none of the differences reached statistical significance.

The Eurofit tests are well-established measures, and this permits some comparison with the published scores of typically developing children and adolescents (Catley & Tomkinson, 2013). This comparison shows that, in general, the younger girls score more poorly than their typically developing peers, and in all the tests but the bleep test this discrepancy is marked. For the older girls this markedly poorer performance is again evident except in the bleep test where they are on par. In the case of the boys, the pattern is the same, though the senior boys' performance on the broad jump was somewhat nearer to their peers than the younger boys.

The body mass index (BMI) is a well-established parameter which is sometimes used as a proxy measure of fitness. The results from the sample's BMIs reveal that the boys average BMI is higher in the older age group, though both age groups show a very wide range of scores. None of the boys' BMIs were below the third centile; however, 23 of the boys had a BMI that was above the 97th for their age. There were only 21 girls in the sample, and they showed an increase in average BMI scores between the age groups. Again none were below the third centile, with four of the younger girls having a BMI above the 97th for their age. Norms for the BMI of typically developing children (Cole, Bellizzi, Flegal & Dietz, 2000) show that the younger boys nearly all fall within the healthy range, but the older boys tend towards having BMI scores above the healthy range, with the median being on the upper limit of the range. Examining the scores for the girls, the median

Table 1: Fitness scores of the boys, by age

	Age ≤ 11, n = 70						
	Minimum	**Maximum**	**Mean (μ)**	**Std. deviation (SD)**	**Median ($\bar{x}$)**	**Coefficent of variance (σ)**	**Published norms for healthy range[a]**
Height (cm)	118	157	140	8.4			
Weight (kg)	23	65	40.9	8.4			
BMI	14.6	33.1	21.1	4.2			Min = 13 Max = 19
$VO_{2\ max}$	1.7	71.6	21.9	16.3			μ = 51.6 SD = 3.9
Bleep test	0	14			3	1	$\bar{x}$ = 3.5 σ = 0.5
10 × 5m run	47	169			74	0.6	Not available
Broad jump	29	147			58.5	0.6	$\bar{x}$ = 143 σ = 0.1
Sit-ups	0	21			9	0.5	$\bar{x}$ = 24.5 σ = 0.7
Flex test	−40	0			−10	−0.8	$\bar{x}$ = 20.5 σ = 0.3
	Age ≥ 12, n = 9						
	Minimum	**Maximum**	**Mean (μ)**	**Std. deviation (SD)**	**Median ($\bar{x}$)**	**Coefficent of variance (σ)**	**Published norms for healthy range[a]**
Height (cm)	147	182	166.3	13.11			
Weight (kg)	40	92	64.7	16.2			
BMI	16.4	33.3	23.3	5.37			Min = 14 Max = 23
$VO_{2\ max}$	3.3	39.6	12.9	15.3			μ = 50.1 SD = 5.2
Bleep test	2	6			3	1.3	$\bar{x}$ = 5.6 σ = 0.4
10 × 5m run	50	156			81	0.6	Not available
Broad jump	45	180			140	0.7	$\bar{x}$ = 177 σ = 0.1
Sit-ups	6	26			17	0.4	$\bar{x}$ = 43.5 σ = 0.4
Flex test	−15	−5			−7	−0.8	$\bar{x}$ = 21.8 σ = 0.3

Note: [a] BMI = Cole et al., 2000; $VO_{2\ max}$ = Léger & Lambert, 1982; Eurofit scores = Catley & Tomkinson, 2013.

Table 2: Fitness scores of the girls, by age

	Age ≤ 11 n = 15						
	Minimum	**Maximum**	**Mean (μ)**	**Std. deviation (SD)**	**Median ($\bar{x}$)**	**Coefficent of variance (σ)**	**Published norms for healthy range[a]**
Height (cm)	115	156	137.63	12.17			
Weight (kg)	30	59	38.83	8.65			
BMI	14.9	26.6	20.51	3.58			Min = 13 Max = 20
$VO_{2\ max}$	5	41.5	16.9	9.9			μ = 49.2 SD = 3.2
Bleep test	0	8			1	2	$\bar{x}$ = 2.4 σ = 0.5
10 × 5m run	53	200			70	0.5	Not available
Broad jump	29	110			60	0.8	$\bar{x}$ = 126 σ = 0.1
Sit-ups	1	26			6	1.3	$\bar{x}$ = 25.6 σ = 0.6
Flex test	−40	0			−9	−1.2	$\bar{x}$ = 24.4 σ = 0.3
	Age ≥ 12 n = 6						
	Minimum	**Maximum**	**Mean (μ)**	**Std. deviation (SD)**	**Median ($\bar{x}$)**	**Coefficent of variance (σ)**	**Published norms for healthy range[a]**
Height (cm)	142	166	155.16	8.99			
Weight (kg)	40	55	47.66	5.88			
BMI	15.2	24.8	20.33	4.31			Min = 14 Max = 24
$VO_{2\ max}$	1.7	43.8	11.23	15.8			μ = 41.6SD = 4.7
Bleep test	2	8			3	1.6	$\bar{x}$ = 3.2 σ = 0.5
10 × 5m run	54	140			77.5	0.5	Not available
Broad jump	55	180			90	0.8	$\bar{x}$ = 153 σ = 0.1
Sit-ups	13	23			16	0.5	$\bar{x}$ = 35.3 σ = 0.5
Flex test	−14	0			−7	−1	$\bar{x}$ = 29.4 σ = 0.2

Note: [a] BMI = Cole et al., 2000; $VO_{2\ max}$ = Léger & Lambert, 1982; Eurofit scores = Catley & Tomkinson, 2013.

again falls on the upper limit of healthy in the younger girls, but the senior girls, although few in number, all are within the healthy range.

The bleep test score was used to obtain an estimate of cardio-pulmonary function by calculating the $VO_{2\ max}$ for each child using the method described by Léger and Lambert (1982). The results showed that the boys' scores ranged from 1.8 to 98.8, and the girls from 1.7 to 55.8. The average $VO_{2\ max}$ scores for the adolescents are at a very low level when compared to published norms (Léger & Lambert, 1982). The norms have been described in a different way by Heyward (1998), and these indicate that for adolescent boys a score of less than 25ml/kg/min (well below the mean for this sample) should be viewed as 'very poor', with 31–5ml/kg/min being rated 'fair'. For adolescent girls, less than 35ml/kg/min (again well below the mean of this sample) is rated as 'very poor', with 38–45 being rated 'fair'.

To examine the association between the various elements, a correlation matrix was prepared, and because some of the data sets had been shown to be non-parametric, Kendall's tau was used as the measure of statistical association. The results from a correlation matrix, controlling for age (Table 3), showed that in boys the BMI was significantly correlated with the bleep test and the 10 x 5 metre run score. Not surprisingly, the bleep test also showed a highly significant association with the 10 x 5 metre run score. By contrast, the girls' results identified no fitness tests that had a significant correlation with the BMI, and there was no statistically significant correlation between the bleep test and the 10 x 5 metre run. The girls' sit-up scores showed some association with the bleep test, but the latter's most statistically significant association was with the broad jump score. The flexibility test showed no association with any other fitness parameter measured.

There has been continuing criticism that the established BMI calculation is inaccurate when dealing with individuals who are tall or short in stature. In view of this a proposed variation of the BMI calculation (Hale, 2012) was used and the results correlated with the fitness measures (Table 3). The results showed movement towards better correlation on all the tests, but did not change the statistical significance of any.

Finally, because the $VO_{2\ max}$ is considered a good measure of cardio-pulmonary fitness, these scores were compared to each child's BMI, and in the boys this revealed a significant association ($r = -0.289$, $df = 76$, $p < 0.01$), but no such association was evident in the girls ($r = -0.25$, $df = 18$).

Table 3: Correlation (using Kendall's tau) of growth parameters and fitness scores, by gender and controlling for age (boys, n = 79; *girls*, n = 21)

	BMI		BMI variation		Bleep test		10 × 5m run		Broad jump		Sit-ups		Flex test	
Cardiopulmonary function ($VO_{2\,max}$)	*0.24*	0.21**	*0.28*	0.21**	*0.65****	0.83***	*0.18*	0.33***	*0.37**	0.18*	*0.28*	0.14	*–0.01*	−0.04
BMI			*0.85****	0.84***	*0.12*	0.22**	*0.26*	0.33***	*0.1*	0.07	*0.06*	0.14	*–0.18*	−0.03
BMI variation					*0.25*	0.23**	*0.29*	0.37***	*0.15*	0.14	*0.13*	0.18*	*–0.12*	0.00
Bleep							*0.27*	0.39***	*0.55****	0.23**	*0.49***	0.21*	*–0.17*	−0.04
10 × 5m run									*0.02*	0.27***	*0.04*	0.23**	*0.24*	−0.02
Broad jump											*0.41**	0.22**	*0.19*	−0.26
Sit-ups													*0.2*	−0.03

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Discussion

The results from this study indicate that children with ASC who also have moderate to severe intellectual difficulties show a wide range of fitness levels, as measured by the $VO_{2\ max}$ score, with most having a worryingly low score. The $VO_{2\ max}$ score is considered to be the optimum measure of fitness, being the strongest independent mortality predictor for cardiovascular disease in healthy people (Katzmarzyk, Church & Blair, 2004; Kemi et al., 2005; Tjønna et al., 2009). Its direct assessment requires measuring oxygen uptake while exercising, but it can be estimated quite well using results from a shuttle run exercise (Léger & Lambert, 1982). Traditionally, however, the child's BMI has been used as the proxy measure (Joshi, Bryan & Howat, 2012).

There has been persistent concern about the validity of using BMI as a marker of fitness (for example, McGee & Diverse Populations Collaboration, 2005; Ode, Pivarnik, Reeves & Knous, 2007; Ahima & Lazar, 2013), with the main criticism being that BMI does not always change, even though a person may be getting healthier (Ross & Janiszewski, 2008). This is because the established BMI calculation tends to exaggerate thinness in short people and fatness in tall people (Trefethen, 2013), and so a variation of the calculation has been developed (Hale, 2012) which seeks to reduce this distortion. In the present study there were higher correlation scores with the BMI variation, but this increase was not sufficient to reach statistical significance with regard to the fitness assessment. This suggests that its value as a measure of cardio-pulmonary fitness is somewhat limited.

Studying children with both ASC and intellectual disability draws together two strands of fitness research. Studies that focused on children with intellectual disabilities have shown that they tend to have lower standards of fitness and poorer levels of cardiovascular endurance than their typically developing peers (Law et al., 2006; Guideti, Franciosi, Gallota, Emerenziani & Baldari, 2010). Existing research has also shown that the fitness levels of children in this group are influenced by several factors including gender, age and level of intellectual disability (Skowroński, Horvat, Nocera, Roswal & Croce, 2009). The studies that have focused on children with ASC have confirmed that this group do show improvement in physical fitness when they increase their exercise levels (Fragala-Pinkham, Haley & O'Neil, 2008; Pitetti, Rendoff, Grover & Beets, 2007; Yilmaz, Yanardag, Birkan & Bumin, 2004), and that physical exercise helps prevent health problems such as heart disease (Pan, 2008; Pitetti et al., 2007). However, these studies have also shown that even when involved with successful physical fitness programmes, children with autism do not reach the levels of physical fitness shown by their typically developing peers (Golubović, Maksimović, Golubović & Glumbić, 2012). This is of significant concern because decreased physical activity is one of the primary reasons for the increased rate of obesity in children with autism (Okely, Booth & Patterson, 2001), and, in general, this group of children are more likely to be obese than their typically developing peers (Ghaffari et al., 2010; Curtin, Anderson, Must & Bandini, 2010). Thus, children with both intellectual disability and ASC are struggling with two potentially negative influences on their physical fitness. The implications of such health inequalities are discussed in the review by Marmot (2010).

One potential reason why children with ASC are not showing the same physical benefits from fitness programmes as their typically developing peers is that the core difficulties of children with ASC make the development of effective fitness programmes particularly difficult. The National Curriculum for Physical Education (DfE, 2013) is statutory in all maintained, mainstream schools up to and including Key Stage 4, and assumes the ability of children to participate in team sports which are extremely challenging for this group of children. Indeed even more general fitness activities bring with them huge challenges for children on the autistic spectrum, from noise levels in sports halls and having to change clothes, to the loss of predictable routine and acting in an unstructured space. Although special educational settings can make some adjustments to environment and lesson content, the core activities remain broadly similar to those in mainstream settings, and so present many of the same challenges in establishing effective physical exercise programmes.

It is well recognised that appropriate levels of physical exercise reduce obesity and cardiovascular risk, but in children with ASC there can also be much wider benefits, with vigorous exercise also being associated with decreases in stereotypical behaviours, hyperactivity, aggression, self-injury and destructiveness (Yilmaz et al., 2004; Oriel, George, Peckus & Semon, 2011; Sowa & Meulenbroek, 2012). In addition, there can be improvements in the academic functioning of children with ASC (Kern, Koegel, Dyer, Blew & Fenton, 1982; Powers, Thibadeau & Rose, 1992) and their academic engagement (Nicholson, Kehle, Bray & van Heest, 2011), as well as improvements in their general psychological health (Janssen & Leblanc, 2010; Schmalz, Deane, Birch & Davison, 2007). Thus giving priority to the achievement of better levels of physical exercise can have great benefits for children with ASC. Recognising the issues that obstruct this goal points to the need to produce programmes that focus upon more insular activities, have a recognisable routine to their content, and are undertaken in a frequently used and familiar space.

With regard to the assessment of fitness, there continues to be considerable debate as to whether using a test-based format to assess the functioning of children with disabilities is the most helpful way forward. Following Rowland's (1995) assertion that testing is meaningless and often not used appropriately, there has been a plethora of studies trying to assess the activity levels of children with ASC. These have produced conflicting results about the amount of activity engaged in by children, particularly out of school (Rosser-Sandt & Frey, 2005; MacDonald, Esposito & Ulrich, 2011). Reviewing the studies, Bandini et al. (2013) have concluded that the level of activity for children with ASC is only less than typically developing children on weekends, although their parents reported the activity levels to be generally far less than they expected. The findings from this study point to a very wide range of fitness levels among the children, and although there was statistical significance between the tests, this was at best modest, indicating that the assessment, as a battery of instruments, is reporting on a wide range of fitness elements. This is not too surprising since the Eurofit was designed for that purpose, but the results presented here suggest that it is also effective in children with ASC. In addition, the $VO_{2\ max}$ can be estimated from one of the elements, giving it a clear advantage over BMI when trying to determine an individual child's level of fitness.

In any such study there are limitations to the conclusions that can be drawn. In this case the sample was drawn from a small geographical area which was urban in nature. The results may thus not fully represent the national picture, and this is particularly true for girls with ASC who were a small part of the sample. In addition the children in the study had learning difficulties, as well as ASC, making it difficult to be confident about whether the findings can be taken to represent the impact upon children with ASC who do not exhibit such difficulties. Thus the scores and ranges for the various assessments should be considered as suggestive rather than definitive. Also, although efforts were made to engage the children in the testing, the nature of ASC reduces the confidence that all of the children made the maximum effort on each assessment element. To this end three trials were undertaken which might have led to some bias of the results. However, since the tests required the children to make their best effort, trying to achieve this by familiarisation was judged to be the more important consideration.

Conclusion

There is growing concern about the impact of reduced activity on children's future health. Children with ASC may be at greater risk because of their greater tendency to obesity (Ghaffari et al., 2010), though whether their physical activity levels are lower than those of their typically developing peers is still being debated (Bandini et al., 2013). The results from this study suggest that, generally, children attending specialist educational settings for ASC have much poorer scores on fitness tests than their typically developing peers. While this study is too parochial to offer a set of norms that can be assumed nationally, anecdotally the findings in this study are not unusual. Johnson (2012) has stated that results obtained from assessment processes such as this need to be contextualised by disability type, examined individually, and adjusted according to the environmental context in which it is being measured. It may be that specific norms that are influenced by specific factors such as parental attitude, community and environmental factors need to be developed, but too specific a set of caveats would render the results meaningless. The study described here illustrates that a degree of accurate fitness testing can be undertaken with children with ASC, and that it is important to do so to identify those who may need more personalised exercise programmes to address poor fitness levels.

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