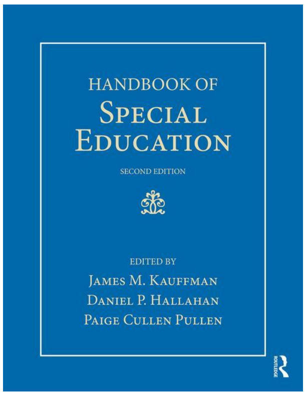

Handbook of Special Education

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Physical Education

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Physical Education

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Being able to move efficiently is one of the critical factors needed to develop and maintain an active lifestyle, which contributes to both the quality and longevity of one's life. Conversely, failure to develop these abilities places one at risk of acquiring a number of health risks such as cardiovascular disease, obesity, diabetes, hypertension, and high cholesterol. As result of these trends, research over the years in the areas of motor development and physical fitness has concentrated on identifying physical and motor developmental benchmarks, valid and reliable measures of these traits, as well as the development and evaluation of programs to develop these traits in both children and adults with and without disabilities. The purpose of this chapter is to review the research related to motor development and physical fitness in relation to children and youth with intellectual disability (ID), learning disability (LD), emotional disturbance (ED), and autism spectrum disorder (ASD).

This chapter is divided into five sections. The first four sections review the research related to physical and motor development in students labeled as ID, LD, ED, and ASD. The research reviewed was delimited to articles published in the past 32 years and to articles listed in the SPORTDiscus database, which includes the primary journals in the field, as well as select earlier studies and studies in other journals that had significant impact on research in the field. The last section of the chapter identifies a number of issues and challenges facing future research on physical and motor development in students labeled ID, LD, ED, and ASD as well as some recommendations on how these issues and challenges may be addressed.

Intellectual Disabilities

Early Research

Research on the physical fitness and motor skill development of individuals with intellectual disabilities is a relatively new area with the majority of the research being conducted since the late 1950s. Early research in this time period was largely descriptive and focused on describing the discrepancies observed between the performance of students with and without intellectual disabilities on a variety of physical fitness/motor skill measures. In one of the classic early studies, Francis and Rarick (1959) examined the gross motor abilities of students with intellectual disabilities and compared their performance with normative data. The participants were 284 students with intellectual disabilities in the Milwaukee and Madison, Wisconsin public schools between the ages of 7.5 and 14.5 years. The students were assessed on measures of strength, power, balance, and agility. The performance of the children with intellectual disabilities was inferior on all measures when compared to the normative data and these discrepancies increased with age. Similar findings were reported by other researchers (e.g., Auxter, 1966; Brace, 1968; Carter, 1966; Malpass, 1960; Sengstock, 1966), but the results were hard to interpret and compare because of differences in sample sizes and characteristics, and different dependent measures. Some of these issues were addressed in 1970 when the American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD) Youth Physical Fitness Test was modified and national norms for both male and female students labeled educable mentally retarded (EMR) ages 8–18 were developed (Rarick, Widdop, & Broadhead, 1970). In this study of 4,235 students, the researchers found that although the changes in performance by age trends were similar to those found for non-disabled students, the performance of the students with intellectual disabilities was inferior to non-disabled students on all measures. Gender differences were also similar between the groups, with the males performing better than females on all measures.

Although research during the 1950s–1970s frequently used the terms fitness and motor skill, the majority of this research actually focused on physical fitness. The confusion is due to the nature of the dependent measures used during this period to measure physical fitness. Many of the fitness measures were confounded by motor skill. For example, a common test for arm and shoulder strength (a fitness measure) was the softball throw (a motor skill) for distance. This test assumed that the students being tested had the prerequisite mature throwing pattern needed to demonstrate their arm and shoulder strength.

With the passage of PL 94-142, the Education of All Handicapped Act of 1975, research began to diversify and focus in four broad areas: descriptive studies, training studies, curriculum development, and assessment studies. The descriptive studies extended the previous research and continued to compare individuals with various levels of intellectual disabilities on select fitness measures (e.g., Fernhall, Millar, Tymeson, & Burkett, 1989; Fernhall, Tymeson, & Webster, 1988; Findlay, 1981; Kasch & Zasueta, 1971; Koh & Watkinson, 1988; Londeree & Johnson, 1974; Pitetti & Campbell, 1991). Another area of descriptive research during this period focused on the prevalence of obesity in individuals with intellectual disabilities. These studies focused primarily on adult populations due to the absence of valid measures and prediction equations for estimating percent body fat in children with intellectual disabilities (Kelly & Rimmer, 1987; Rimmer, Kelly, & Rosentsweig, 1987). The findings of these studies consistently showed that the prevalence of obesity was higher in adults with intellectual disabilities (Fox, Burkhart, & Rotatori, 1983; Fox & Rotatori, 1982; Kelly, Rimmer, & Ness, 1986; Kreze, Zelinda, Juhas, & Gabara, 1974; Polednak & Auliffe, 1976) and that the incidence increased as the level of ID decreased (Fox & Rotatori, 1982; Kelly et al., 1986).

A second focus was development and testing of programs to remediate the fitness and motor skill deficits being observed in children with intellectual disabilities. Numerous studies reported findings demonstrating that the fitness of students labeled EMR could be improved via structured physical education programs (e.g., Beasley, 1982; Bundschuh & Cureton, 1982; Campbell, 1974; Corder, 1966; Halle, Silverman, & Regan; 1983; Maksud & Hamilton, 1975; Nordgren, 1971; Nunley, 1965; Oliver, 1958). For example, Solomon and Pangle (1967) used a treatment (N = 24) and control group (N = 18) design and found that the levels of physical fitness of boys with EMR could be significantly improved via an eight-week training program and these changes were retained over a six-week period following the study. Findings also indicated that the improved fitness scores of the boys with EMR were comparable to the performance levels of boys who were not EMR.

Another focus that paralleled the research on training was on the development and field testing of comprehensive physical education programs. Several of these programs were funded by the Department of Health, Education, and Welfare's Bureau of Education for the Handicapped. Most notable of these were Project Active (Vodola, 1973, 1978), I CAN (Wessel, 1977), and Database Gymnasium (Dunn et al., 1980). The I CAN project is briefly described here to illustrate both the focus and magnitude of these projects. I CAN was composed of eight boxes of physical education resources specifically designed to address the physical education needs of students with intellectual disabilities. Each box addressed one of the major physical education goal areas: fundamental motor skills, physical fitness, social skills, body management skills, team sports, aquatics, outdoor activities and backyard/neighborhood activities, and dance and individual sports. Within each goal area (e.g., fundamental motor skills), the content was broken down into objectives (e.g., running, throwing, catching), and each objective was further tasked analyzed into three skill levels and within each skill level by focal points that defined the key qualitative performance criteria. Then, for each objective the following resources were provided: assessment items, instructional activities for each focal point within the assessment items, and games keyed to each focal point. The roots of Project I CAN can be seen today in Everyone CAN (Kelly, Wessel, Dummer, & Sampson, 2010), which is an elementary physical education curriculum designed to accommodate all students, and the Test of Gross Motor Development (Ulrich, 2000), a normative test of gross motor skills for children aged 4.5–11 years.

The significance of these curriculum development projects was that they expanded the focus from physical fitness to the full range of content addressed in physical education. Although the emphasis on fitness is still dominant today, some progress has been made on increasing research in the area of motor skill development. Unfortunately, because of the reduction of federal funds that underwrote the costs of producing the materials and providing schools with the training needed to implement them, all of these previously funded curricula have subsequently gone out of print.

The fourth general focus that emerged was research on developing and validating assessment items. Much of this work was in the area of physical fitness and particularly on developing and evaluating valid measures of cardiorespiratory endurance for use with individuals with intellectual disabilities (Burkett & Ewing, 1983; Coleman, Ayoub, & Friedrich, 1976, Cressler, Lavay, & Giese, 1988; Fernhall, Millar, Tymeson, & Burkett, 1990; Fernhall & Tymeson, 1988). There have been two extensive reviews on this topic (Fernhall et al., 1989; Lavay, Reid, & Cressler-Chaviz, 1990). These reviews concluded that there are a number of issues that complicate the measurement and cross-study comparisons of cardiovascular fitness on individuals with intellectual disabilities including: (a) the heterogeneity of the population, (b) the reality that one standardized protocol will not likely work for all individuals, (c) many individuals require significant amounts of training to learn how to perform the testing protocol reliably, and (d) motivation and intra-individual variability are difficult to control with students with intellectual disabilities.

Recent Research

As the 1990s approached, research continued in the previously described areas and expanded to address an even broader spectrum of questions. To illustrate the foci of recent research, we searched the SPORTDiscus database to identify research from 1985 to date using the search terms intellectual disability, mental retardation, physical fitness, motor skills, motor development, children, youth, and adolescents. Delimiting the findings to research studies that applied to school-aged individuals with mild intellectual disabilities produced 77 studies. Table 38.1 shows the distribution of these studies by focus (i.e., physical fitness, motor skill, and physical education) and by type of research (descriptive, training, assessment, and other). The physical education focus and the other research category includes studies that either combined fitness and motor skill measures and/or focused on other measures such as on-task behavior, student interactions, effects of peer tutors, or student attitudes. The articles in each of these categories are summarized below to provide an overview of the current direction and emphasis of research in the field.

Fitness—descriptive studies. The majority of the descriptive research involving school-aged individuals with intellectual disabilities since 1990 can be grouped in two broad categories: comparison studies and general descriptive studies. The comparison studies typically involve comparing individuals with intellectual disabilities with individuals without intellectual disabilities on various fitness items such as running (e.g., Frey, McCubbin, Hannigan-Downs, Kasser, & Skaggs, 1999; Pitetti & Fernhall, 2004), physical activity (e.g., Faison-Hodge & Porretta, 2004; Foley, 2006), strength (e.g., Pitetti & Yarmer, 2002), body composition (e.g., Pitetti, Yarmer, & Fernhall, 2001), or between different cultures (e.g., Chow, Frey, Cheung, & Louie, 2005; Onyewadume, 2006). An example of a study in this category was by Lahtinen, Rintala, and Malin (2007), which monitored the physical performance of 33 females and 44 males with intellectual disabilities over 30 years in Finland. Participants were evaluated four times starting in 1973 (ages 11–16), again in 1979 (ages 17–22), 1996 (ages 34–39), and 2003 (ages 41–46). They used four dependent measures consistently across the four measurement periods: Body mass index (BMI), sit-ups, stork stand, and pearl transfer. The BMI is calculated by dividing body weight in kilograms by height in meters squared. During early adolescence there was no difference between BMIs of adolescents with intellectual disabilities compared to norms of Finnish students without intellectual disabilities. However, over the next two measurement periods the BMIs of the individuals with intellectual disabilities increased significantly over the comparative norms with 70% of the individuals with intellectual disabilities having BMI values greater than 25 and females having significantly higher BMI values than males. Results for abdominal strength revealed that during early adolescence the individuals with intellectual disabilities could perform only half as many sit-ups as the normative group and their performance declined further over time with 40% of the participants not being able to perform a single sit-up as adults. The stork stand was used to measure static balance. The early adolescents with intellectual disabilities performed significantly lower than the comparison group on the initial measure. Their performance increased slightly during late adolescence and then declined consistently over the last two measures with a third of the adults not being able to balance on one foot for one second. Finally, manual dexterity was measured by a pearl stringing task. The findings for this measure paralleled the abdominal strength and balance results with the performance of the individuals with intellectual disabilities starting out significantly lower than the comparison group, then showing a significant improvement between the first and second measurement and then showing a significant decline in adulthood with all levels being below the comparison group.

TABLE 38.1
Distribution of Research Studies Reviewed from 1985 to 2008

Article Focus	Fitness	Motor Skill	Physical Education
Descriptive Research	15	1	
Training	11	15	
Assessment	20	2	
Other			13

Articles grouped in the general descriptive category focused on topics such as physical work capacity (e.g., Fernhall & Pitetti, 2001), cardiovascular fitness (e.g., Fernhall et al., 1988), physical activity (e.g., Levinson & Reid, 1991; Sit, McKenzie, Lain, & McManus, 2006), fitness variations (e.g., Waldemar, Horvat, Nocera, Roswal, & Croce, 2009), and profiles of elite athletes with ID (e.g., Van de Vliet et al., 2006). A sample of the research in this category is illustrated by the study by Sit et al., whereby they investigated the physical activity levels of children with mild intellectual disabilities attending two special schools for children with mild intellectual disabilities in Hong Kong. Participants were 80 children in Grades 4–6 with IQs between 50 and 70. Schools were purposefully selected based on emphasis on sport performance. One school was labeled high sport (HS) performance and the other low (LS) based on the number of students who had previously qualified for international competitions. Students' physical activity was observed and recorded using SOFIT during physical education and two separate recess periods during four days across two weeks. SOFIT is a coding system that involves time sampling and coding of student physical activity, lesson context, and teacher behavior. MANOVA results revealed that there were no overall school differences with regard to physical education between the schools. The data did reveal the following trends: students in the HS school had less time for physical activity but tended to engage in more vigorous physical activity in both physical education and recess whereas students in the LS school had more time for physical activity. Findings were compared to the Healthy People 2010 recommendations for physical activity and previous findings on children in the United States. Physical activity levels demonstrated by the students in this study were just short of the Health People 2010 recommendations, but above those typically reported for children both with and without disabilities in the United States.

Fitness—training studies. The second major category within physical fitness is training studies. These studies tend to focus on the effects of a type of training program (e.g., aerobics, swimming, Pilates), on some aspect of fitness (e.g., lung function or health-related fitness; see, for example, Can et al., 2005; Etherton, Covington, Burt, & Weishaar, 2006; Khalili & Elkins, 2009; Ozmen, Yildirim, Yuktasir, Beets, 2007), or on psycho-social effects (e.g., Dykens, Rosner, & Butterbaugh, 1998; Lee & Dummer, 2006; Wright & Cowden, 1986) of fitness training. It should be noted that the majority of the training studies involving individuals with intellectual disabilities used adult participants rather than children.

The study by Wright and Cowden (1986) illustrates a training study that examined the effect of a swimming program on the cardiovascular endurance and self-concept of adolescents with intellectual disabilities. Participants were 50 adolescents ages 12 to 18 classified as mildly and moderately mentally retarded. These subjects were divided into two groups. One group participated in a Special Olympics swim training program for one hour a day, two days a week, for ten weeks. The second group served as the control and performed their normal daily activities including attending their regular physical education classes during the ten weeks of the study. All participants were pre- and post-tested using the nine-minute run/walk test and the Piers-Harris Children's Self-Concept Scale. Analysis of variance results revealed significant mean differences between the Special Olympics group and the control group on both dependent measures. On the nine-minute run-walk test, the Special Olympics group demonstrated significant improvement between the two measurement periods whereas the control group actually showed a slight decline in their performance. Similar results were found on the self-concept measure. The control group showed no change, but the Special Olympics group demonstrated a significant improvement. Implications were discussed regarding the value of organized youth sports programs like Special Olympics for individuals with intellectual disabilities and the need for more research in this area.

In addition to the research cited here, there have also been two published reviews of research in the area of training. Chanias, Reid, and Hoover (1998) reported a meta-analysis of 21 studies that focused on the health-related physical fitness of individuals with intellectual disabilities, and Fernhall (1993) reported a summary of the training research on fitness and intellectual disabilities. These reviews revealed that individuals with intellectual disabilities have lower levels of fitness, higher risks for cardiovascular disease, and may respond differently to exercise training. They also found large effect sizes for exercise training on cardiovascular endurance and muscular endurance and moderate effect sizes for training focusing on muscular strength. However, no significant effects were found for body composition. Both reviews concluded with recommendations for future research and identified issues in the areas of experimental design and standardization of methods that needed to be addressed.

Fitness—assessment. The last category of fitness research on individuals with intellectual disabilities includes studies that focused on assessment issues related to physical fitness. The majority of these studies focused either on cardio-respiratory endurance (e.g., Baumgartner & Horvat, 1991; Beets, Pitetti, & Fernhall, 2005; Ellis, Cress, & Spellman, 1993; Fernhall, Millar, Pitetti, Hensen, & Vukovich, 2000; Pitetti, Millar, & Fernhall, 2000; Koh & Watkinson, 1988; Pitetti, Fernhall, Stubbs, & Stadler, 1997; Watkinson & Koh, 1988) or physical activity of individuals with intellectual disabilities (e.g., Faison-Hodge & Porretta, 2004; Horvat & Franklin, 2001; Kozub, 2003; Lorenze, Horvat, & Pellegrini, 2000; So-Yeun & Joonkoo, 2009; Stanish, 2004).

A study that investigated the validity and reliability of the one-half mile run-walk test as an indicator of aerobic fitness for children with intellectual disabilities by Fernhall, Pitetti, Stubbs, and Stadler (1996) illustrates research in the area of cardiorespiratory assessment. In this study, 23 students labeled as mildly or moderately mentally retarded and ranging in age from 10 to 17 years were measured on two maximal treadmill protocols with metabolic measurements and two one-half mile run-walk trials. Participants were familiarized with both the testing settings and protocols before being tested. Fernhall et al. (1996) measured peak VO2 and heart rate during the treadmill tests, time to the nearest second to complete the one-half mile run-walk, and heart rate during the run-walk. There were no significant differences between the two trials for VO2 max, maximum heart rate, or run-walk time. Correlations between trials were $r = .90$ for VO2max, $r = .81$ for maximum heart rate, and $r = .96$ for the one-half mile run-walk indicating that the ½ mile run-walk was a reliable test. Based on the correlation between VO2 max and the one-half mile run walk $r = .60$ ($p < .05$) and the comparison of this relationship to data previously reported on children without mental retardation, the authors concluded that the one-half mile run-walk had questionable validity as an indicator of aerobic capacity for children with mental retardation.

An investigation by Horvat and Franklin (2001) illustrates a study designed to examine physical activity in children with intellectual disabilities. Participants in this study included 23 children from three different schools, ages 6 to 12, classified as mildly mentally retarded. Participants were observed for sixteen minutes using an interval recording system (i.e., Scheme for Observing Activity Level) on three different occasions while engaged in free play in two types of recess settings (inclusion and non-inclusion) and in the classroom. During each observation period, the students also wore a heart rate monitor and an activity monitor. Students in the two recess settings were significantly more active than in the classroom setting and there was no significant difference found between the two recess settings. The authors noted that while there were no statistical significant differences found between the two recess settings, they did observe that the non-inclusive setting provided higher activity ratings when compared to the inclusive setting.

Readers interested in more information about fitness assessment for individuals with ID, should consult excellent literature reviews on this topic by Frey, Stanish, and Temple (2008) and Seidi, Reid, and Montgomery (1987).

Motor Skill Studies

The second major category of research studies reviewed here pertains to studies that investigated questions related to how motor skills were acquired (e.g., Edison & Stadulis, 1991; Gillespie, 2003; Porretta & O'Brien, 1991; Surburg, Porretta, & Sutlive, 1995; Yang & Porretta, 1999) by students with intellectual disabilities and/or how students with intellectual disabilities learned motor skills in different settings (e.g., Kozub, 2002; Valentini & Rudisill, 2004) or factors that affect learning in physical education (e.g., Gagnon, Touslgnant, & Martel, 1989; Holland, 1987; Kozub, Porretta, & Hodge, 2000; Merighi, Edison, & Zigler, 1990; Shapiro & Dummer, 1998; Temple & Walkley, 1999; Yun & Ulrich, 1997). Motor skills in this section refer to fundamental motor patterns used in our societal games and sports such as the locomotor and object control skills of running, skipping, catching, and throwing. The studies on motor skills have been divided into two areas: motor learning studies and field-based studies in physical education settings.

Motor learning. Motor learning studies focus on how motor skills are learned and/or under what conditions they are learned most efficiently. Most motor learning studies are conducted in laboratory or highly controlled field settings. For example, Gillespie (2003) investigated summary versus every-trial knowledge of results for individuals with intellectual disabilities. Knowledge of results (KR) involves giving the learners feedback either mechanically or verbally about the outcome of their performance. Participants for this study were 32 males with mild ID with a mean age of 10.75 years. The task involved putting a golf ball from a designated spot with a regulation club and ball. Students were oriented to the task which involved putting a ball and having it stop between two horizontal lines located 144 in. (370.08 cm) and 156 in. (400.92 cm) in front of the students. After the students understood the task, an opaque curtain was placed 60 in. (152.40 cm) in front of the students that prevented them from seeing where their ball stopped. Students were then given 50 putting trials. Both groups received visual (i.e., were able to look around the curtain and see where their ball stopped) and verbal feedback (i.e., score indicating distance from target). Students in the KR1 group received KR feedback after each trial whereas students in the KR5 group received summary feedback after every five trials. Retention was measured one day and one week after the acquisition trials. Analysis of the data revealed that students in the KR1 group obtained statistically significant higher scores during the skill acquisition trials than the students in the KR5 group. However, students in the KR5 group obtained significantly higher scores on both the one-day and one-week retention tests.

Readers interested in learning more about the theoretical basis of research on motor learning and motor skill acquisition of individuals with ID should consult the book by Michael Wade (1986) and the article by Hoover and Wade (1986).

Physical education studies. We review two studies in this section to highlight the nature of the current research in physical education for intellectual disabilities. The first study examined learning of physical education under different instructional settings. For more information on this topic, readers should consult the review by Block and Obrusnikova (2007). The second study illustrates examples of studies that examined different factors that affect the learning of students with intellectual disabilities in physical education.

Valentini and Rudisill (2004) investigated the effect of an inclusive mastery climate intervention on the motor skill development of children with and without disabilities. Participants were 36 students with disabilities and 68 students without disabilities who were randomly assigned to intervention and comparison groups. The mastery intervention training was based on creating a mastery climate, which was defined as a systematic approach that uses student-centered instruction to target both the motivational level of the student and the processes of learning. It is a type of climate where the primary emphasis is on the autonomy of the child. The teacher facilitates an instructional environment in which students are given the opportunity to navigate their own learning that they deem appropriate for their level of development. The focus of a mastery climate is directed toward the process rather than on the product or outcome of learning (p. 332). All participants were pre- and post-tested on the TGMD, which was composed of six locomotor and six object control skills. The intervention group participated in a twelve-week intervention that met twice a week for sixty minutes and was based on a mastery climate and focused on locomotor and object control skills. The comparison group participated in free play under the supervision of a classroom teacher over the twelve-week period. Both groups participated in their regular physical education program that met twice a week. Both the students with and without disabilities that participated in the intervention demonstrated significant improvement in the motor performance whereas the participants in the comparison group did not.

Temple and Walkley (1999) investigated the academic learning time of students with mild intellectual disabilities in regular physical education classes. Academic learning time (ALT) is a measure of teacher effectiveness that employs a systematic observation system to quantify the percentage of time students spend engaged in the subject matter at an appropriate difficulty level. Different types of engagement can be measured. This study focused on physical education time (PE-Time), physical education engagement time (PE-Engaged), the amount of time engaged in motor practice (ME) and engagement in motor activity at the appropriate difficulty level (MA). Participants for the study were drawn from integrated primary and secondary schools in Australia sampling students from Grades 3, 4, 5, 8, 9, and 10. A quota sampling technique was used resulting in 24 students with mild intellectual disabilities and 48 students without disabilities matching a male and female student to each student with intellectual disabilities. The class containing each student was observed five times. Data were recorded using an interval recording procedure. Data analysis revealed no significant effects for the variable grade or interaction of grade with gender or disability. Overall 59% of the allocated class time was spent on PE-Time. Of this total, 35% was spent on PE-Engaged time and of this 26% was ME and 22% was of the appropriate difficulty level. Although there were no differences between the students with and without intellectual disabilities on PE-Time, students with intellectual disabilities were engaged 40% less in motor activity at the appropriate level. The authors argued that students with intellectual disabilities were not being provided a curriculum appropriate to their intellectual ability.

A second search of the SPORTDiscus database was performed to identify research from 2009–2016 using the search terms: intellectual disability, mental retardation, physical fitness, physical activity, motor skills, motor development, children, youth, and adolescents. Delimiting the findings to research studies involving school-aged participants with intellectual disabilities produced a total of 16 studies, which could broadly be divided into two categories: ten interventions studies and six comparative studies. The ten intervention studies involved treatments designed to improve specific motor skills (n = 5), social skills (n = 3), or areas of physical fitness (n = 2). The motor skill studies focused on a variety of different interventions designed to improve motor performance on target skills: the effects of a five-day bike training program (Ulrich, Burghardt, Lloyd, Tiernan, & Hornyak, 2011); the effects of an eight-week martial arts training program (Maslesa, Videmsek, & Karpljuk, 2012); the effects of an eight-week adapted basketball program (Stanišić, Berić, Bojić, Nurkić, & Kocić, (2014); the effects of a four-week basketball program (Radenkovic, Beric, & Kocic); and the effects of a Special Olympics training program for track events (Luiselli et al., 2013). Three of the intervention studies examined the impact of various types of training programs on both motor skill performance and social skills: the effects of a ten-month table tennis program on tennis and social indicators (Francova, 2014); the effects of a five-month Special Olympics program on motor and social skills (Ciocan, Alexe, & Mares, 2016); and the effects of an eight-week structure physical activity program on emotional self-control (Choi & Cheung, 2016). The fitness studies focused on a three-month training program to improve standing posture and walking performance (Hayakawa & Kobayashi, 2011) and a five-month training program designed to improve balance (Drzewowska, Sobera, & Sikora, 2013). The six comparative studies compared the performance of individuals with ID with non-disabled groups. Four of these studies focused on motor skills and compared Finnish children with and without IDs on the Test of Gross Motor Development (Rintala & Loovis, 2013); motor abilities of students with mild ID with non-disabled students (Protić-Gava & Uskoković, 2016); reaction time after exercise with non-disabled performances (Selickaitė, Rėklaitienė, & Požėrienė, 2014); world records of individuals with ID with non-disabled world records (Tilinger, 2013); the Eurofit special fitness battery for use with individuals with IDs (Skowronski, Horvat, Nocera, Roswal, & Croce, 2009); and the relationship between alignment of upper limbs and postural control for individuals with Down Syndrome (Saeid, Hassan, Noureddin, 2014).

Summary of Literature

This brief review of the literature on research in physical education related to individuals with mild intellectual disabilities clearly shows that this is a significant area of interest and that a substantial amount of research has been conducted. Overall the findings reveal that individuals with mild intellectual disabilities tend to perform below their age equivalent peers without intellectual disabilities, but that with appropriate instruction these deficits can be reduced. With regard to gender, males tend to perform better than females. Within the population of individuals with intellectual disabilities, deficits in performance tend to increase as the severity of the intellectual disabilities increases. Although the volume of research produced to date is encouraging, the majority of it has focused largely on one aspect of physical education—physical fitness and within physical fitness predominantly on cardiorespiratory endurance. Acquisition of motor skills, which constitutes the majority of the content in physical education, has received less emphasis in the research literature, and a significant body of this research has focused on the learning of novel skills and/or has employed indirect measures of learning such as academic learning time.

Children with Learning Disabilities

Many children with learning disabilities do not display gross motor problems and are actually quite athletic. Famous athletes with learning disabilities include Olympic gold medalist Bruce Jenner, basketball star Magic Johnson, football star Dexter Manley, and baseball star Pete Rose (Angle, 2007). However, many children with learning disabilities have motor problems (Shaeffer, Law, Palatajko, & Miller, 1989). Sherrill and Pyfer (1985) found 13% of children with learning disabilities scored 2–3 years below age level on perceptual motor tests, Miyahara (1994) found that 25% of children with LD scored poorly in a general motor ability test, and Sugden and Wann (1987) found that 50% of 8-year-olds and 29% of 12-year-olds had motor problems. Not surprisingly, motor problems are most notable in children with motor and sensory-related learning problems such as dyspraxia and visual processing problems (Conrad, Cermak, & Drake, 1983; Shapiro, 2001).

SPORTDiscus was used as the primary search engine with the terms "learning disabilities" and "motor," "motor delays," "physical education," or "fitness" as the targeted search words. The final total of 52 articles were categorized as (a) cause of apraxia and movement problems in learning disabilities (3 articles), (b) motor development/performance/ability (22 articles), (c) practice/learning/teaching factors and their effect on performance (11 papers), (d) testing/evaluation (7 papers), and (e) psychological variables such as self-esteem/expectancies/effort (9 papers). Each of these areas is reviewed highlighting key findings and trends from the data.

Motor Development, Performance, and Ability

As noted earlier, research shows 13% to 50% of children with learning disabilities have motor deficits. Most research related to motor performance in children with learning disabilities has focused on confirming and then specifying these delays. The vast majority of these studies examined specific motor coordination problems in children with learning disabilities using either the Bruininks-Oseretsky Test of Motor Proficiency (BOT) (Beyer, 1999; Bluechardt & Shephard, 1996; Bruininks & Bruininks, 1977; Longhurst, Coetsee, & Bressan, 2004; Pyfer & Carlson, 1972; Schaeffer et al., 1989), or the Test of Motor Impairment (TOMI) (Cermak, Ward, & Ward; 1986; Geuze & Borger, 1993; Losse et al., 1991). Both of these tests measure general coordination, eye-hand coordination, response speed, static and dynamic balance. Most of these studies were well conceived with an age-matched control group and group-sizes of 30 or more participants. Results from these studies confirm that many children with learning disabilities have delays when compared to peers without learning disabilities. For example, Longhurst and her colleagues in South Africa compared the motor proficiency in 60 children 8–12 years of age with and without learning disabilities on the BOT. Children without learning disabilities performed significantly better on all eight subtests compared to children with learning disabilities, with most notable differences in balance, strength, and upper body speed and dexterity. Similarly, Bleuchardt and Shephard in Canada found children with learning disabilities 8–10 years of age scored significantly lower than the normative sample on the BOT. As with Longhurst et al., the greatest deficits were in balance and upper body speed and dexterity, although strength deficits were not significant as was the case in Longhurst et al.

Other researchers examining coordination looked at one specific aspect of coordination, again finding differences between children with and without learning disabilities. These studies were well conceived, with age-matched control groups and relatively large group sizes ranging from 12 to 30 participants. For example, Fawcett and Nicolson (1992), Getchell, McMenamin, and Whitall (2005), Rousselle and Wolff (1991), Wolff, Michel, Ovrur, and Drake (1990), and Yap and Van der Leij (1994) found children with learning disabilities had more difficulty in consistency and coordinating two tasks at one time such as walking and clapping or balancing and listening compared to age-matched peers without learning disabilities. Woodard and Surburg (1999) found children 6–8 years of age with learning disabilities demonstrated midline crossing inhibition compared to age-matched peers without learning disabilities. Kerr and Hughes (1987) found children 6–8 years of age were 1–2 years delayed compared to age-matched peers in a reciprocal finger-tapping task. Lazarus (1994) found children with learning disabilities 7–14 years of age had greater levels of overflow (an inability to keep one arm or leg still while moving the other arm or leg) compared to same-age peers without learning disabilities. Finally, Smits-Engelsman, Wilson, Westenberg, and Duysens (2003) found children ages 9–12 with learning disabilities and developmental coordination disorders had no problems with simple drawing tasks (drawing a line from one target to another) but did differ from peers without learning disabilities in cyclical drawing tasks (drawing a line back and forth between two targets).

Finally, research found many children with learning disabilities performed at a lower developmental level compared to peers without learning disabilities in fundamental motor patterns (Bradley & Drowatzky, 1997; Woodard & Surburg, 1997, 2001). For example, Woodard and Surburg compared 22 children with and without LD 6–8 years on the Test of Gross Motor Development (TGMD). The TGMD measures qualitative performance on six locomotor (e.g., run, gallop) and six object control (throw, catch) skills. The test provides age norms for comparison. Results found 12 of 22 children with LD performed at a delayed level including six children scoring at a poor level and four children at a very poor level. In contrast, eight of 22 children without LD performed at a delayed level, but of these eight only four performed at a poor level, and none performed at a very poor level.

Psychological Variables Related to Motor Difficulties in Children with LD

Motor difficulties and repeated failures in gross motor performance in physical education, recreation, and sport settings that can lead to psychosocial problems related to these movement problems (Doyle & Higginson, 1984; Henderson, May, & Umney, 1989; Shaw, Levine, & Belfer, 1982; VanRossum & Vermeer, 1990; Willoughby, Polatajko, & Wilson, 1995). For example, Shaw and her colleagues measured self-esteem in a total of 23 boys with learning disabilities (12 with gross motor delays) aged 8–12 years using two different scales of self-esteem. Boys with poor coordination self-reported themselves lower in physical ability, social relationships, and happy qualities compared to boys without motor delays. This study should be read with some caution given the small sample size and use of self-esteem scales in which participants were read 80 questions for one scale and 48 for the other (quite a bit of listening and thinking for children as young as 8 years of age). However, Willoughby et al. found similar lower motor-related self-esteem in children with learning disabilities and related motor difficulties with a larger sample (85 children) and stronger instruments (i.e., the Bruininks-Oseretsky Test of Motor Proficiency to measure gross motor performance and the Pictorial Scale of Perceived Competence and Social Acceptance for Young Children to measure self-esteem).

Children with LD and motor difficulties are more likely to experience less success in physical education and, as a result, develop behaviors in an attempt to avoid physical activity (Dunn & Dunn, 2006; Thompson, Bouffard, Watkinson, & Causgrove Dunn, 1994). Dunn and Dunn observed 65 fourth- to sixth-grade children with movement difficulties and 65 matched children without movement difficulties in general physical education classes. Children with movement difficulties in a general physical education setting spent less time successfully performing assigned activities, spent more time experiencing difficulty in the given tasks, and spent more time in off-task behaviors when compared to peers without disabilities.

Not all studies examining children with learning disabilities show a relationship between movement and self-esteem. Shapiro and Ulrich (2002) examined physical/motor self-esteem in 30 children with and without learning disabilities aged 10–13 years using the Modified Pictorial Scale of Perceived Physical Competence (MPSPPC). Results indicated no differences in perceived physical competence between children with and without learning disabilities. Interestingly, children with learning disabilities in this study did not have any motor problems or problems in physical education as reported by their physical education teachers, which may account for these findings. Similarly, Kozub and Porretta (2001) found no differences between fifth-grade children with and without learning disabilities (12 children per group) on measures of task persistence. Children in this study were given two physical activity tasks that could not be completed successfully. However, both children with and without learning disabilities showed similar persistence scores in these tasks, suggesting children with learning disabilities do not get frustrated more quickly than peers without disabilities. Again, there was no indication whether the children with learning disabilities in their study had concomitant motor deficits, which may have altered the results, and the small sample size brings into question the strength of the study.

Teaching-Learning Variables and Motor Performance in Children with Learning Disabilities

Several researchers have investigated ways to enhance motor performance in children with learning disabilities who have movement difficulties. Some researchers examined ways of improving fundamental motor patterns such as throwing and catching and running and jumping (Hodge, Murata, & Porretta, 1999; Revie & Larkin, 1993; Valentini & Rudisill, 2004). The common thread in all these studies was the focus on teaching the components of the skills and setting a climate focusing on skill mastery rather than competition. For example, Hodge and his colleagues found mental preparation (closing one's eyes and going through the components of the skill to be performed) significantly improved throwing patterns in elementary-aged children with learning disabilities and attention deficits compared to matched participants who did not do a warm up or did a traditional stretching warm up. Similarly, Revie and Larkin used task-specific, intensive teaching instruction to help children aged 5–9 years with movement problems improve in fundamental movement patterns of the overarm throw, target kick, and bounce-and-catch tasks. Hodge et al. assigned children to either a group (N = 12) which was taught the over-arm throw and hop or to a group (N = 12) which was taught target kick or volleyball bounce-and-catch. Each group acted as the other's control group, and (with the exception of hopping) pretest-posttest scores showed significant improvement when the specific skill was taught, but there was no such improvement without instruction. This is important because physical educators too often simply introduce skills and then move to new skills. Such an approach does not seem to match the needs of students with learning disabilities, who require intense instruction on specific skills programs and distributed practice if they are to master skills.

Others have examined more specific treatments or techniques on mastery of more discrete, motor learning tasks. Results of these studies showed that constant practice schedules improved learning of a simple motor task compared to random practice schedules (Heitman, Erdmann, Gurchiek, Kovaleski, & Gilley, 1997); verbal rehearsal strategies improved performance in a motor sequencing task compared to no modeling and even visual–verbal modeling (Kowalski & Sherrill, 1992); relaxation training improved reaction time on a visual choice motor test as well as reducing unrelated behaviors (Brandon, Eason, & Smith, 1986); and a specialized school-based (Khalsa, Morris, & Sifft, 1988) and home-based (Horvat, 1982), and cooperative program (Mender, Kerr, & Orlick, 1982) improved balance in children with learning disabilities). For example, Hietman and his colleagues compared practice schedules on learning three different versions of the same skill in 24 children aged 9–12 years with learning disabilities. Children were randomly placed in either a constant or variable practice schedule. In the constant practice schedule, children practiced one variation of the skill continuously for ten trials before moving to the next variation of the skill. In the variable practice group, children practiced each variation of the skill ten times but in random order. Both groups received the same grand total of 30 practice trials. Results showed children in the constant practice group performed significantly better compared to the variable group during learning. However, there were no differences between the groups on the following day when both groups were presented the task randomly. Results showing constant practice improves performance during the learning phase is consistent with the motor learning research. However, motor learning research also shows random practice improves performance in retention tasks and when transferring to a slightly different skill (Schmidt & Wrisberg, 2008). Unfortunately, Hietman and his colleagues did not examine retention or transfer, so it is still unclear which practice schedule is best for children with learning disabilities.

Regarding teaching-learning programs it is important to note the controversy surrounding perceptual-motor training and children with learning disabilities (Dunn & Leitschuh, 2006; Hallahan & Cruickshank, 1973; Kavale & Mattson, 1983; Nolan, 2004). Perceptual-motor training as a treatment for learning disabilities was popular in the 1960s and 1970s based on clinical, classroom, and anecdotal reports of success remediating specific learning problems. The basic concept behind the theory is that perceptual-motor problems cause learning problems. For example, Kephart (1971) suggested a strong relationship between finding a figure from its background (a perceptual task) and success in academic tasks such as reading and writing. Kephart created a remedial program for children with learning disabilities grounded in perceptual-motor training including balance and posture, locomotion, and eye-hand coordination. Similarly, Getman and Frostig created visual-perceptual training programs, and Ayres created a sensory integration program, all with the idea that perceptual-motor training will improve academic performance (Dunn & Leitschuh, 2006).

Unfortunately, analysis of hundreds of studies showed perceptual motor training was not an effective method to remediate specific learning disabilities (Hallahan & Cruickshank, 1973; Kavale & Mattson, 1983). Schaeffer et al. (1989) pointed out perceptual-motor training quickly fell out of favor with the learning disability community in the 1980s, leading the Council for Learning Disabilities (Board of Trustees, 1986) to issue a position statement opposing "the measurement and training of perceptual and perceptual-motor functions as part of learning disability services" and called for "a moratorium on assessment and training of perceptual and perceptual-motor functions in educational programs" (p. 247). Interestingly, perceptual-motor training has seen a recent resurgence in programs for children with learning disabilities, including Educational Kinesiology/Brain Gym (Cammisa, 1994; Freeman & Dennison, 1998), which includes stretching and unique movements designed to stimulate brain function, and the Dore Method (Dore, 2010), which includes balance activities, throwing and catching bean bags, and a range of stretching and coordination exercises. Both programs purport to improve academic function in children with learning disabilities, but these methods have yet to be supported by empirical research.

A second search of the SPORTDiscus database was performed to identify research from 2008–2016 using the search terms "learning disabilities" and matched with physical activity, exercise, sport or movement or activity. Only articles from 2008 to the present were included. No articles were found using this search criterion. However, there have been several articles about children with developmental coordination disorder (DCD) (e.g., Adams, Ferguson, Lust, Steenbergen, & Smits-Engelsman, 2016; Au et al., 2014; DeMilander, Coetzee, & Venter, 2015; Jie et al., 2016). While DCD is not part of the definition of learning disability, DCD can be viewed as a specific learning disability in the area of motor control. Apparently researchers interested in motor development and motor control in children with learning disabilities have focused on the specific case of DCD.

Children with Emotional Disturbances

There has been very little published on motor development delays/issues or physical activity levels of children labeled as emotionally disturbed. Perhaps this is due to the broad definition of behavior disorder that includes everything from conduct disorder to depression to anorexia to anxiety disorder. It may also be due to the fact definitions and characteristics of specific types of behavior disorders do not include any motor of fitness delays (APA, 2000; Downing, 2007). A search was conducted of SPORTDiscus using key disability terms *behavior disorder*, *behavior disability*, *emotional disorder*, and *emotional disability.* These disability terms were then matched with the terms *physical activity*, *physical education*, *motor*, *recreation*, and *sport.* Combined, these searches produced several hundred articles. Interestingly, most of the articles focused on anorexia or ADHD or were not focused on motor or physical activity. However, there were seven articles found in this search that were appropriate for this review. Two of these articles focused on attitudes towards physical activity (Merriman, 1993; Politino & Smith, 1989). For example, Politino and Smith compared the attitude toward physical activity and self-concept of children with emotional disturbances aged 8–13 years from two psychiatric hospitals (n = 80) to 390 children of the same age without emotional disturbances. Data was collected using two surveys—the Children's Attitude toward Physical Activity Inventory and the Piers-Harris Self-Concept Scale. Results found that children without disabilities had significantly higher attitudes toward physical activity and a higher level of self-concept compared to children with emotional disturbances. Two studies focused on using physical activity (in this case dance) to promote appropriate behaviors (Edwards-Duke, Boswell, McGhee, & Decker, 2002) or using behavior modification in a physical activity to promote appropriate behavior (Jeltma & Vogler, 1985). The remaining three studies examined actual physical activity, motor proficiency or skill development in children with behavior disorders (Bar-Eli, Hartman, & Levy-Kolker, 1994; Gruber, Hall, McKay, Humphries, & Kryscio, 1989; Maiano, Ninot, Morin, & Bilard, 2007). To illustrate, Maiano and his colleagues studied effects of sport participation (basketball) on basketball skill development and physical self-concept in 24 boys with conduct disorders aged 11–13 who attended one of two special schools in France. Participants were divided into one of three groups: competitive basketball at the special school; competitive basketball in an integrated, community program; and a control group that received regular physical activity but not competitive basketball. A basketball skill test and self-concept test were administered four times over an eighteen-month period. Results showed the two competitive groups significantly improved their basketball skills from pre- to posttest, while the control group did not see such an improvement. However, there were no statistical improvements in self-concept in any of the groups from pre- to posttest.

Similarly, there were only three articles that were somewhat on topic with the combination of behavior disorder and recreation, but these articles focused on the effects of therapeutic recreation settings (e.g., adventure-based program, out-patient therapeutic recreation program) on social skill development or appropriate behavior (Bloemhoff, 2006; McMahon & Sharpe, 2009; Rothwell, Piatt, & Mattingly, 2006). In addition, in our own records we found two additional articles that focused on recreation and children with emotional disorders, but again these articles focused on the use of recreation settings (outdoor challenge program, leisure education program) on self-esteem or attitudes towards leisure (Langsner & Anderson, 1987; Munson, 1988).

In summary, there were very few studies that examined motor delays or physical activity issues in children with emotional disturbances. Most of the research focused on the use of physical activity, sport and recreation on improving self-concept, behaviors and attitudes towards physical activity. There is nothing in the literature or in descriptions of sub-populations of children with behavior disturbances that suggest these children have motor delays or problems with physical activity. On the other hand, limited access to community sport and recreation programs due to behavior issues and poor attitudes towards physical activity makes this population prone to physical inactivity and all the unwanted effects of physical inactivity such as obesity and health problems.

A second search of the SPORTDiscus database was performed to identify research from 2008–2016 using the search terms "behavior or emotional disabilities" and matched with physical activity, exercise, sport or movement or activity. Only articles from 2008 to the present were included. Fifteen articles were found using this search criterion. However, only nine of these papers were research-based. Five papers focused on the use of exercise as an intervention with those with behavior disorders (e.g., Brown, Pearson, Braithwaite, Brown, & Biddle, 2013; Rėklaitienė, Gaižauskienė, Ostasevičienė, & Požėrienė, 2014; Samalot-Rivera & Porretta, 2013), including two that focused specifically on the effects of exercise on those with post-traumatic stress disorder (PTSD) (Bennett, Lundberg, Zabriskie, & Eggett, 2014; Scioli-Salter et al., 2016). There also were three studies on those with eating disorders (Filaire, Treuve, & Toumi, 2012) including three examining college athletes with eating disorders (Carrigan, Petrie, & Anderson, 2015; Gapin & Petruzzello, 2011; Kong & Harris, 2015). It should be noted that only three of the studies presented above focused specifically on children (Brown et al., 2013; Rėklaitienė et al., 2013; Samalot-Rivera & Porretta, 2013).

Autism Spectrum Disorder (ASD)

Autism spectrum disorder (ASD) has been one of the fastest growing developmental disabilities, now affecting 1 in 68 children according to the most recent CDC report (Christensen et al., 2016). ASD is defined by two traits present from birth: (1) severe deficits in social communicative behaviors (SCD); and (2) highly restrictive, repetitive behaviors (RRB; APA, 2013). Much of the previous research on ASD has focused on these two key areas, and for good reason, as deficits in these areas can severely limit daily function. However, a growing body of research over the past decade has focused on the motor development of children with ASD (Staples, MacDonald, & Zimmer, 2012). This body of research has demonstrated strong evidence of a delay or deficit in the motor development of children with ASD (Liu, Hamilton, Davis, & ElGarhy, 2014; Lloyd, MacDonald, & Lord, 2013; Staples & Reid, 2010).

Interestingly, concerns surrounding the coordination and movement patterns of children with ASD is not a new concept and has been present since the earliest reports of ASD research. Kanner (1943), in an analysis of several boys with "autism characteristics," suggested that the children appeared "clumsy" and lacked motor control. A year later, Hans Asperger (1944; Asperger & Frith, 1991), independent of Kanner (1943), described these participants as "clumsy" and "gauche" (p. 90). In the early 1990s the World Health Organization (WHO, 1993) stated in The International Classification of Diseases, 10th Edition (ICD-10) that clumsiness appears to be a common feature of ASD, but is not required or essential for diagnosis. Surprisingly, the motor development of children has gone largely unanalyzed until the last decade. Ghaziuddin and Butler (1998), in one of the first accounts of this new focus of research, found that all 45 of their participants with pervasive developmental disorders (PDD) demonstrated issues of motor coordination, with the highest rate of "clumsiness" in children diagnosed with autism. Berkeley, Zittel, Pitney, and Nichols (2001) in analyzing the motor characteristics of 15 children with ASD found that nearly all children with ASD were below average, with the majority falling in the "poor" or "very poor" ranges of the age-matched norms for the Test of Gross Motor Development (TGMD; Ulrich, 1985). Further, Berkeley et al. (2001) reported that during locomotor testing in particular, participants seemed to focus more on the product of the movement (e. g., A to B) than on the process (i.e., how to do it). While motor delays appear to be a common characteristic in children with ASD, there is limited understanding of whether these delays are due to some underlying, inherent neurological damage associated with ASD or due to a combination of the hallmark factors, such as limited communication and repetitive behaviors. This lack of conclusive evidence as to whether motor impairments are inherent to ASD limits motor characteristics use in the diagnostic process even though evidence of delay can often occur prior to delays in other key aspects of ASD (Liu, 2012; Teitelbaum et al., 2004).

Motor Characteristics of ASD

In order to best understand how to assist individuals with ASD to improve motor skills and overall fitness, it is important to understand how motor development occurs across the life span of individuals. Since this is a relatively new area of focus for autism research and much of the current focus of the autism community is on the epigenetic of the disorder, little longitudinal research has been done on the development of motor skills. Therefore, we must look to the cross sectional studies to gain an understanding of what the motor characteristics of individuals are at each age level. Using the SPORTDiscus database, the research reviewed revealed two main age group focuses: (1) infants and toddlers, and (2) early childhood to young adulthood. Little has currently been done on the motor characteristics of adults with ASD, although this area is likely to see an increase in research in the coming years. In the next paragraphs, the findings of the motor characteristics of each age group will be discussed.

Infants and toddlers. With the drive for early intervention (Lord et al., 2006) and the potential mitigating effects of early motor development on early language development and social skills (Bedford, Pickles, & Lord, 2016; MacDonald, Lord, & Ulrich, 2013), reaching children with ASD early with interventions is imperative. Until recently, with the advent of more robust screening measures such as the ADOS (Lord et al., 2000) and increased national awareness of ASD, diagnosing ASD at very young ages has been difficult. While many children with ASD receive their diagnosis around 3 years of age, for many others this may not happen until they start school a few years later (Mandell, Novak, & Zubritsky, 2005). Understanding motor characteristics of infants and toddlers has been limited, but recent studies (Liu, 2012; Lloyd et al., 2013; Matson, Mahan, Fodstad, Hess, & Neal, 2010) have demonstrated that motor skills of infants and toddlers with ASD are severely delayed. For example, in an exploratory analysis of 44 children with ASD (32 males, 12 females), Liu (2012) demonstrated a delay in 26 motor milestones (e.g., sitting with support, crawling, etc.), according to parental report, with 11 being statistically different from normative data for children who were developing typically. These results offer an extremely useful account of the motor characteristics of children with ASD, and support previous accounts of delayed motor milestones (Ming, Brimacombe, & Wagner, 2007). Moreover, Liu et al.'s findings provide evidence that motor-skill deficits may be present in children with ASD long before SCD present themselves, which presents an argument for including motor development to be included in the diagnostic assessment.

Lloyd et al. (2013) provide strong additional evidence for delayed motor skills in young children with ASD. They collected data on 162 participants between the ages of 12 and 36 months from a large research database in which participants had no known genetic disorders besides ASD at entry into the study. Fifty-eight participants were measured a second time approximately twelve months later, which provided one of the few longitudinal analyses of skill development for this population. Employing a direct measure for motor ability (MSEL), results suggest that all participants were below the expected scores for chronological age. Moreover, gross motor development slowed significantly as the children aged. In addition to demonstrating deficits in motor abilities and the increasing gap as children age, Lloyd et al. used non-verbal problem-solving skills as a covariate within their analysis to account for the potential of unrecognized intellectual disabilities (ID) to bias the results. Since significant deficits still occurred despite controlling for potential identifiers of ID, this would suggest that cognitive ability is not responsible for the motor delays and supports the theory that motor deficits in children with ASD are not a secondary problem but, rather, are inherent to the condition (Lloyd et al., 2013; Ozonoff et al., 2008).

Early childhood to young adulthood. Unfortunately, the outlook for motor delays and deficits in children with ASD do not improve as they mature into adolescence and young adulthood (see Fournier et al., 2010, for an overview of the coordination of individuals with ASD across several age groups). Several recent studies found motor delays and deficits present in childhood (Liu & Breslin, 2013a; Whyatt & Craig, 2012) through adolescence (Green et al., 2009; Jasiewicz et al., 2006) and into young adulthood (Abu-Dahab, Skidmore, Holm, Rogers, & Minshew, 2012). There are no known studies of the motor characteristics of adults with ASD; this will warrant future research as the large population of children with ASD ages and requires additional services (Turcotte, Mathew, Shea, Brusilovskiy, & Nonemacher, 2016). Furthermore, deficits in early childhood through adolescence are present in individuals with ASD compared to peers without ASD (Liu et al., 2014) and developmentally matched peers (Staples & Reid, 2010). Even so, delays and deficits may not be universal across the autism spectrum (Dewey, Cantell, & Crawford, 2007). In a recent analysis of 21 children with ASD (M age = 7.57 years) and 21 age-matched typically developing children (M age = 7.38), Liu et al. (2014) found that the overall gross motor scores of children with ASD were significantly different ($p = .002$) from those of their peers without ASD. Furthermore, effect sizes, as determined by Cohen's d, were large on the locomotor subtest (ES = 1.12), object-control subtest (ES = 1.07), and overall gross motor quotient (ES = 1.00). These results provide important information about how children with ASD perform motor skills compared to their peers. However, several aspects of the study raise concerns about over-interpreting the results. As with many studies of individuals with ASD, the sample size is small, and therefore findings are difficult to generalize to the broader population. Second, MacDonald, Lord, & Ulrich (2014) suggest that the severity of the symptoms (i.e., SCD and RRB) of ASD affects the individual's gross motor abilities (i.e., the more severe the symptoms, the lower the gross motor score). Liu et al. (2014) did not report this in their analysis; perhaps participants in their sample were on the more severe end of the autism spectrum in terms of overall symptoms, and therefore results would differ significantly in individuals with fewer ASD-specific symptoms.

Staples and Reid (2010) further provide evidence that suggests a deficit in motor skills among children and adolescents with ASD. Twenty-five children with ASD (M age = 11.15 years; 21 males, 4 females) were compared to three separate comparison groups without disabilities, each individually matched on either (a) chronological age, (b) movement skill performance, or (c) mental age. Using the locomotor and object-control raw scores from the TGMD-2 (Ulrich, 2000), Staples and Reid (2010) showed a significant difference between children with ASD and the chronological age-matched ($p < .01$) and mental age-matched ($p < .01$) groups. There was no significant difference between the children with ASD and developmentally matched group (M age = 5.87) on locomotor ($p = .72$) or object-control ($p = .81$) skills, suggesting that children with ASD tend to perform motor skills at a level about half their age. Staples and Reid stated that all of the participants with ASD were able to perform each of the skills of the TGMD-2. However, all participants demonstrated difficulty in coordinating movements, especially between sides of the body or arms and legs. Staples and Reid suggested that difficulties in performing object-control tasks (e.g., throwing, striking, dribbling a basketball), could stem from limited exposure to and practice of the skills.

Models of Intervention

As with research on the overall motor characteristics of individuals with ASD, research focused on methods of intervention of motor skills is also limited and plagued by small sample sizes. Again, using the SPORTDiscus database, recent research was analyzed regarding the current best practices for helping children with ASD improve their motor skills. Two types of intervention for ASD became event during the literature searches: (1) physical activity based, and (2) motor skill based. The predominant research of each area will be discussed in the following paragraphs.

Physical activity intervention. Recent evidence suggests that individuals with ASD are not likely to engage in high levels of physical activity (Pan & Frey, 2006), and rates are likely to decline as the child ages (MacDonald, Esposito, & Ulrich, 2011; Memari et al., 2012). Yet, several recent studies and literature reviews provide positive evidence for the use of exercise-based interventions to assist with motor and social deficits in individuals with ASD (Bremer, Crozier, & Lloyd, 2016; Sowa & Meulenbrowk, 2011; Strahan & Elder, 2013). However, small sample sizes limits the findings' generalizability. Furthermore, the suggested effects of exercise and physical activity on ASD are limited due to the great variance among individuals with ASD. Nevertheless, when looking at the research in this area as a whole, evidence for increasing the physical activity of individuals with ASD is overwhelmingly positive. Furthermore, the general focus of physical activity intervention has been more focused on increasing physical activity and decreasing unwanted behaviors, while being less focused on actual skill development.

Bremer et al. (2016), in a recent review of 13 studies, focused on the impact of exercise interventions on behavioral outcomes for children and youth (≤ 16 y/o) with ASD. Bremer et al. reported that a total of 11 behavioral outcomes were assessed across the 13 studies, and outcomes were divided into three broad categories: stereotypic behaviors (i.e., SCD and RRB), cognitional and attention (i.e., on-task behavior, academic responding, and work performance), and social-emotional behavior (i.e., adaptive skills, social skills, and problem behaviors). Overall, the interventions included suggest that exercise can be an effective method to address behavioral issues in children with ASD. However, the variance between studies on frequency, intensity, type, and dosage made avenues for future research or practical implications difficult to identify. Furthermore, the variation in what constituted "exercise" provides little practical guidance. This diversity was further demonstrated in the meta-analysis by Sowa and Meulenbroek (2011). Overall, in a limited number of studies (n = 16), Sowa and Meulenbroek suggest that exercise-based interventions have a positive effect on both the motor and social skills of individuals with ASD. Even so, the variability between studies, again, makes practical suggestions difficult. Individual interventions, compared to group interventions, seemed to provide a greater benefit for individuals with ASD. Unfortunately, similar to the conclusions of Bremer et al. (2016), the variability among participants in each of the studies Sowa and Meulenbroek reviewed provides little in terms of generalizability and must be interpreted on an individual level based on severity of ASD.

Motor skill intervention. Although numerous interventions have been developed to address various aspects of the characteristics of ASD (McDonald & Machalicek, 2013; Wong et al., 2013), few address the development of motor skills in children with ASD. Instead, the majority address the core stereotypic characteristics of ASD. This lack of attention to motor skills is critical, given recent findings that link motor skill development and social and language development in children with ASD. A literature review revealed few studies (n = 7) focused on motor interventions for improving FMS in children with ASD. Three of the most recent studies (Bremer & Lloyd, 2016; Bremer, Balogh, & Lloyd, 2014; Ketcheson, Hauck, & Ulrich, 2016) demonstrated an increasing awareness of the needs of children with ASD in relation to motor development. For example, Bremer and colleagues (2014), in a small sample (n = 9) pilot study of 4-year-old children with ASD, demonstrated an FMS intervention's positive effect on gross motor skills, as well as improvements in adaptive behavior and social skills. This intervention consisted of twelve hours of direct instruction given over either six weeks (two hours per week) or twelve weeks (one hour per week). The intervention covered all FMS (e.g., running, hopping, leaping, throwing, catching, etc.) and was delivered either 1-on-1 or 1-on-2, following a similar format each week: warm-up, review of previous skill, direct instruction on new skill, practice of new skill, obstacle course, free play, and clean up (Bremer et al., 2014). This intervention mimicked the flow of a typical physical education (PE) or adapted physical education (APE) class. Although the intervention demonstrated a positive influence on the development of FMS in young children with ASD, little information was provided as to the prompts and instruction for each skill except that the delivery method was direct instruction, likely due to limitations of space in publishing. In a similar format, Bremer and Lloyd (2016) applied a similar strategy in a school-based setting for five children with ASD and ASD-like symptoms (3–7 years of age). Again, the intervention was provided in PE/APE-like format: warm-up, review of previous skill, instruction on and practice of new skill, obstacle course, and clean up, and concluded with an opportunity to play with a ride-on bike as a reward. An instructional example was provided that detailed the use of visuals, environmental cues, verbal cues, and physical prompting. Given in two six-week blocks consisting of thirteen-and-a-half hours of 1-on-1 instruction, Bremer and Lloyd identified improvements in many individual items, as well as overall improvement in locomotor skills for four of the participants and in object control skills for three of the participants. Further, while there is merit to providing instruction within the constraints of the classroom setting, devoting one week to each skill may not provide enough instruction to sustain growth in motor abilities.

Although Bremer et al. (2014), Bremer and Lloyd (2016) and the other reviewed studies support the effectiveness of motor interventions to build motor skills in children with ASD, only limited information is available about what should be done or how interventions should be delivered. Bremer et al. provide some insight into instructions and content, but information is limited. Studies by Bremer et al. and Bremer and Lloyd do provide evidence that "single-step instructions, progressive skill acquisition, and visual prompts" (Bremer et al., 2014, p. 68) can be effective in relaying information to children with ASD to assist with motor skills. Research into the effect of visuals (Breslin & Rudisill, 2011, 2013; Liu & Breslin, 2013b) on performance of motor tasks has demonstrated the potential importance of ensuring that the most effective instructional methods are used with children with ASD.

Current Issues and Challenges

Clearly, conducting research in the physical and motor domains presents many challenges when working with students with developmental disabilities (Reid, Dunn, & McClements, 1993). These challenges can range from issues related to recruiting, communicating and achieving informed consent, or preparing participants for participation and encouraging but not coercing compliance with the research protocol. While these are all important challenges, this section is going to briefly touch on three much broader issues: (a) the need for coordinated, multidisciplinary research; (b) the need for uniform, dependent measures for physical and motor skill assessment; and (c) the need for consistent definitions of disabilities.

Research in physical education is generally not guided by any systematic master plan, but instead is largely a collection of small, often one-attempt studies, employing different definitions of participants, dependent measures, testing protocols, and/or training programs. Research in physical education needs to become more multidisciplinary, better integrated with collaborative research in special education, and conducted on a large scale. To this end, it is recommended that the professional associations (e.g., SHAPE America and CEC) work together to conduct a national needs assessment and the creation of a national research agenda for individuals with developmental disabilities that includes physical education. Within physical education it is also recommended that the following issues be addressed:

1. Create and validate physical fitness and motor skill assessment instruments that can be used to measure physical and motor development across the PK–adult age range for individuals with developmental disabilities.
2. Work with state departments of education to infuse these uniform physical fitness and motor skill assessments into the PK–12 school physical education curriculum so that comparable data are collected on all students as part of the normal educational process.
3. Researchers need to partner with local schools to assist in valid data collection, analysis, and interpretation and then to work collaboratively with schools and state education systems in creating large-scale intervention programs to address identified needs that can be replicated and easily transferred to other schools.

Physical education is defined in IDEA as the "development of (a) physical and motor fitness, (b) fundamental motor skills and patterns, and (c) skills in aquatics, dance, and individual and group games and sports (including intramural and lifetime sports)" (Department of Education, 2002, p. 18). The review of research in this chapter reveals that while a substantial amount of research has been conducted in the area of physical education with individuals with developmental disabilities, the emphasis and the focus of the research has not been well balanced. For example, the vast majority of the research on individuals with ID has focused on just one aspect of physical education that is physical fitness and much of that research has focused on only one area of fitness—validating measures of cardiovascular endurance. Future research in physical education, therefore, needs to apply a more balanced approach, which examines all aspects of physical education particularly given the clear relationship between one's ability to move competently and one's ability to stay active and be physically fit. It should also be clear that the majority of the components of physical education are developed and learned at younger ages and therefore require more research efforts at the preschool and elementary levels. Innovative solutions are needed to address the challenges of creating research designs, finding valid dependent measures, and working with younger participants with developmental disabilities.

Finally, the range of physical and motor abilities of students within any given developmental disability label can vary tremendously depending on the nature of the definition and how it was assessed. This is particularly true for students labeled specific learning disability (SLD) and ASD. For example, matching two students on the label SLD may control for little of the variance on a motor assessment due to their disability if one has an auditory processing problem and the other a visual processing problem. Students with LD who have motor delays vary widely from study to study. What further confounds the research is the new label of developmental coordination disorder (DCD). Questions that need to be answered are what percentage of children with LD have DCD, and what percentage of children with DCD have LD? In addition, do children with LD who have DCD or significant motor delays have specific types of learning disabilities (e.g., dyslexia) vs. other types of learning disabilities?

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