The Outcomes of an Adapted Tennis Program in Children and Adults with Developmental Disabilities

by

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Abstract

Individuals with developmental and intellectual disabilities (e.g., Autism Spectrum Disorder, Down Syndrome, Intellectual Disability, etc.) exhibit difficulties performing motor skills and show lower physical activities levels compared to peers without disability. Tennis is an ideal sport for individuals with disabilities because participants can increase their skill levels at their own pace, while still engaging in a social environment (e.g., other participants on the court). This dissertation examined the outcomes from an 8-week adapted tennis program for adults with developmental disabilities (n=27) with respect to motor skill outcomes. Based on the results from this program, modifications were developed to improve the structure of the curriculum including additional visual and behavioral supports for an adapted tennis program specifically for children and adolescents with Autism Spectrum Disorder. The visual supports and behavioral modifications were implemented to augment the basic curriculum provided by ACEing Autism, a national non-profit organization that developed an adapted tennis program for children and adolescents with ASD. The effects of the modified ACEing Autism program are discussed with respect to changes in tennis skills and physical activity levels in children and adolescents with ASD (n=22). Changes in motor appropriate, inappropriate, and supported behaviors in the participants of this program (n=19) were also measured. The results suggested that every participant improved in tennis skills from pre- to post test in both studies adults with DD (n=27) and children with ASD (n=22). In addition, children with ASD spent 50% of the time or more in motor appropriate behaviors and decreased inappropriate behaviors over time. The adapted tennis program can be broadly implemented in other populations, as well as the implications for the implementation in the context of physical education and after-school programs.

Acknowledgments

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Table of Contents

List of Tables

List of Figures

List of Abbreviations

ABA	Applied Behavior Analysis
ABC	Aberrant Behavioral Checklist
ADHD	Attention Deficits Hyperactivity Disorder
ALT-PE	Academic Learning Time-Physical Education
ASD	Autism Spectrum Disorder
BCBA	Board Certified Behavior Analysts
CARS2-ST	Childhood Autism Rating Scale Second Edition
CP	Cerebral Palsy
DS	Down Syndrome
DD	Developmental Delay
DY	Dyslexia
ID	Intellectual Disabilities
IRB	Institutional Review Board
NS	Noonan Syndrome
SOYA	Special Olympics Young Athletes
WHO-DAS	World Health Organization Disability Assessment Schedule

Chapter 1. General Introduction

The prevalence of developmental disabilities, including Autism Spectrum Disorder (ASD), Intellectual Disability (ID), and other developmental delays, has grown from 5.7% in 2014 to 6.99% in 2016 (Zablotsky, Black, & Blumberg, 2017). Individuals with developmental disabilities experience disparities in both mental (Einfeld, Ellis, & Emerson, 2011; Emerson & Hatton, 2007; Platt, Keyes, McLaughlin, & Kaufman, 2018) and physical health (Havercamp & Scott, 2015; Rimmer, Yamaki, Lowry, Wang, & Vogel, 2010). Participation in adapted sports and physical activities offered as part of school curricula (i.e., adapted physical education) and in the community (for review see Ryan, Katsiyannis, Cadorette, Hodge, and Markham (2013) may attenuate health disparities in this population. Indeed, participation in adapted sports, including Special Olympics, is associated with improved social functioning (Dinomais et al., 2010; McConkey, Dowling, Hassan, & Menke, 2013; Shapiro & Martin, 2010a), enhanced self-concept (Crawford, Burns, & Fernie, 2015; Shapiro & Martin, 2010b; Weiss, Diamond, Demark, & Lovald, 2003), improved fitness (Baran et al., 2013; Guidetti, Franciosi, Gallotta, Emerenziani, & Baldari, 2010; Wright & Cowden, 1986), and increased physical activity levels (Walsh et al., 2018). A recent review of outcomes specific to Special Olympics participation reported similar benefits on physical, psychological, and social domains (Tint, Thomson, & Weiss, 2017). However, few studies have measured changes in motor skill development resulting from participation in adapted sports and recreation.

Deficits in fundamental motor skills have been consistently reported for individuals with developmental and intellectual disabilities. Although participation in adapted sports programs should result in improvements in fundamental and sport-specific motor skills, research quantifying these changes is surprisingly sparse and predominantly examines the impact of

Special Olympics programs for children and adolescent athletes. For example, Favazza et al. (2013) examined the efficacy of the Special Olympics Young Athletes program (SOYA; 3x a week, 8 weeks), which teaches fundamental motor skills for sport participation, in young children with ID (ages 3-5 years). They found that children that participated in the SOYA showed a significant improvement in the Peabody Developmental Motor Scales and teacher reported gross motor skills, compared with young children with ID that did not participate in SOYA. In an older group of children (6th-8th-grade students), Castagno (2001) reported improved performance on the Special Olympics Basketball Skill Assessment Test following an 8-week program (1.5 hours of instruction, 3x a week) for Special Olympics athletes and their peer partners. Using a similar training structure (1.5 hours, 3x a week for 8 weeks), Baran et al. (2013) reported improvements in the Special Olympics Football (soccer) Skills Assessment in 12-15 year old Special Olympics athletes and their peer partners. In a study comparing participation across different sports (basketball, swimming, and adapted physical activity) female athletes ages 13-17 years with ID improved in the performance of product-oriented skill assessments during completion over 8 months (Ninot, Bilard, Delignières, & Sokolowski, 2000). Together, these studies support the efficacy of adapted sports programs to develop motor skills in children and adolescents with and without developmental and intellectual disabilities. However, differences in dose of the interventions and a lack of process-oriented measures may limit the generalizability of these results.

To date, a handful of studies have examined improvements in motor skills resulting from adapted sports participation in adults with disabilities. All of these studies examined the effects of competitive Special Olympics programs and used the product-oriented skill assessment tests provided by Special Olympics. For example, Chen, Ryuh, Fang, Lee, and Kim (2019) reported

improvements in the performance of the Special Olympics Football (soccer) Skills Assessment in a broader age range (ages 12-25 years) with and without ID following a 15-week, twice a week adapted soccer program. Two studies have been conducted examining basketball ability in adults with ID. Guidetti, Franciosi, Emerenziani, Gallotta, and Baldari (2009) quantified changes in the performance of the Special Olympics Basketball Skill Assessment Test following a 4-month (4 hours weekly) training program in adults ages 21-43 years with ID. They reported significant improvements from pre- to post-training in fundamental basketball skills in all athletes. Interestingly, the authors also reported that level of impairment (i.e., mild, moderate, severe, profound) influenced the degree of improvement in basketball skills; those with mild or moderate impairments exhibited the most significant improvements in skills compared with those with severe or profound impairments. In a follow-up study, Baldari et al. (2009) examined the effects of a 6-month (4 hour weekly) basketball and strength and conditioning program in adults ages 19-42 years with ID. Similar results were observed; all athletes improved performance in the Special Olympics Basketball Skill Assessment Test from pre- to post-training and the degree of skill improvement was related to the degree of impairment (i.e., mild, moderate, severe, profound intellectual disabilities). Collectively, these studies provide preliminary evidence that completive adapted sport training improves motor skills in adults with ID, but that individual factors such as level of function influence skill improvement.

Many knowledge gaps remain regarding the changes in motor skill resulting from adapted sports programs for adults and adolescents with disabilities. For example, what are the changes in process-oriented skill development? Can shorter duration programs result in similar improvements as those observed previously (i.e., 3- to 6-month-long programs)? Do adapted sports programs confer similar improvements for individuals with other developmental

disabilities? Lastly, would similar improvements result from programs aimed at training new sports skills (i.e., developmental programs vs. competitive program)?

Chapter 2 describes the outcomes from an adapted tennis program for adults with developmental and intellectual disabilities (n=27). We hypothesized that 8-weeks of adapted tennis lessons would improve the performance of forehand and backhand skills in adults with developmental and intellectual disabilities. We further hypothesized that age, disability type, and level of functioning would affect the degree of improvement in the forehand and backhand skills. We hypothesized that the dose of practice would increase over the 8-week intervention and would be positively associated with improvements in forehand and backhand performance.

The results partially support our hypotheses. Overall, the program was effective in improving tennis skills (forehand and backhand) in a short period of time (8-weeks) across a broad age range (19- to 35-year-olds), disability type (i.e., ASD, DS, CP), and level of function. Level of function, but not age or disability type, was associated with changes in forehand and backhand process scores. The number of forehand shots performed during the adapted tennis program did not change across time. The number of forehand shots was associated with age and disability, but not level of function. The number of backhand shots (dose) was not associated with age, disability, or level of function. The number of forehand or backhand shots (dose) was not associated with changes in forehand or backhand process scores, respectively. Taken together, these results suggest that the quality of the practice (and not simply the dose) may be important to consider in future studies examining the efficacy of adapted sports programs on motor skill development in adults with disabilities.

Based on the results from the adapted tennis program for adults with disabilities, we created additional behavioral supports and modifications to address the unique needs of children

and adolescents with Autism Spectrum Disorder (ASD; Chapter 3). Physical educators commonly employ equipment modifications (e.g., different size of balls, racquets, and nets), rule modifications (e.g., changing boundary lines, scoring systems), and various types of instructions (e.g., verbal, modeling, or pictures) to increase participation of children with ASD (Block, 2016; Grenier, 2014; Lavay, French, & Henderson, 2016; Lieberman & Houston-Wilson, 2018). Yet, a primary concern raised by adapted physical educators is the need for additional strategies to reduce behavioral difficulties or challenges, particularly for individuals requiring substantial support (Healy, Judge, Block, & Kwon, 2016). Chapter 3 describes the development and implementation of supplemental behavioral strategies used during an after-school adapted tennis program for children and adolescents with ASD (ACEing Autism). The goal of this chapter is to describe the ACEing Autism program and to provide concrete examples of how behavioral strategies were used to supplement the standard curriculum to increase motor skill learning, on-task behaviors, and enjoyment. We discussed the implementation of these additional supports for two participants with different levels of behavioral supports.

In Chapter 4, we implemented the basic ACEing Autism curriculum with the additional behavioral supports and modifications (described in Chapter 3). We implemented a 4-week adapted tennis intervention with children and adolescents with ASD (n=22, ages 7-19 years) and measured the effects on tennis skills and physical activity levels. It is well-known that beyond core deficits in communication and social interaction, individuals with Autism Spectrum Disorder (ASD) also exhibit poorer motor skills (Fournier, Hass, Naik, Lodha, & Cauraugh, 2010; Kindregan, Gallagher, & Gormley, 2015; Mosconi & Sweeney, 2015; Pan, Tsai, & Chu, 2009) and lower physical activity levels compared to typically developing peers (Bandini et al., 2013; MacDonald, Esposito, & Ulrich, 2011; Pan, 2008). The National Autism Center (2015)

recommends physical activity as an emerging treatment to improve motor and social skills for children with ASD (National Autism Center, 2015). However, motor skill impairments and greater need for behavioral supports may contribute to difficulties participating in traditional recreation and sports programs (Fournier, Hass, Naik, Lodha, & Cauraugh, 2010). Therefore, adapted opportunities for children with ASD via in-school physical education (Block & Obrusnikova, 2007; Bremer and Lloyd, 2016; Grenier, 2014; Lieberman & Houston-Wilson, 2018), summer programs (Guest, Balough, Dogra, Lloyd, 2017; Johnson et al., 2018), and after-school programs (Block, 2016; Pan, 2008) are critical for these children to increase physical activity levels, motor skill development, and social skills. The social, physical activity, and motor skill outcomes from ACEing Autism programs have been measured via parent reports and disseminated to the ACEing Autism program directors; parents report improvements across all domains. However, quantitative measurement of physical activity levels and motor skill outcomes are currently lacking. Therefore, in Chapter 4 we quantitively assessed physical activity levels prior to, during, and after a 4-week ACEing Autism program (2 sessions per week for 1 hour per session) as well as changes in tennis skills before and after the program. Consistent with the parent reports, we hypothesized that all participants would increase levels of moderate-to-vigorous physical activity during the ACEing Autism program and that participants would significantly improve in their tennis skills. We also hypothesized that factors such as age, sex, and level of functioning would affect the magnitude of improvements in tennis skills and amount of physical activity acquired during the adapted tennis program.

Our hypotheses were partially supported. Consistent with the findings from the adapted tennis program for adults with disabilities, the 4-week adapted tennis program resulted in significantly better forehand, backhand, and volley skills. Age, sex, and level of functioning were

associated with changes in the forehand, but not backhand or volley skills. Participants increased the amount of moderate-to-vigorous physical activity levels, compared to the week before or after the adapted tennis program. However, age, sex, and level of functioning were not associated with changes in physical activity levels. These results are very encouraging and are likely due to the structure and supports built into the program. Moreover, these results have important implications for the other ACEing Autism programs, particularly with respect to program duration and fidelity.

In Chapter 5, we quantified motor behaviors (motor appropriate, motor inappropriate, and motor supported) in 19 children and adolescents (ages 7-19 years) that participated in the ACEing Autism program (described in Chapter 4). Previous studies had used a standardized behavioral coding system, the Academic Learning Time in Physical Education (ALT-PE; Miller, 1985; Silverman, Dodds, Placek, Shute, & Rife, 1984), to characterize student and teacher behavior during physical education. This tool has been implemented in two small studies examining behaviors of children with ASD (Fittipaldi-Wert, 2007) and adolescents with ASD (Lisboa, Butterfield, Reif, & McIntire, 1995). These studies found that visual and behavioral supports, respectively, are needed to ensure appropriate behaviors during PE in children and adolescents with ASD. Building upon these studies, we examine the factors that influenced time spent in motor appropriate, motor inappropriate, and motor supported behaviors of age, sex, and level of function on. We hypothesized that overall, participants with ASD would spend a significant amount of time performing motor appropriate behaviors due to the individualized behavioral supports used in the program and highly-trained coaches/volunteers implementing the program. We also hypothesized that overall, participants would show a decrease in time spent in motor inappropriate and supported behaviors over time. Lastly, we also hypothesized that

younger participants and those with lower levels of functioning would spend significantly more time receiving motor support (physically help to perform a task), compared with older participants and those with higher level of functioning.

The results of this study partially support our hypotheses. On average, the participants spent over 50% of the time in MA. The older males spent more time in MA compared with young males, but no age difference was observed for the females. With respect to time spent in MI, males exhibited a significant decrease from 7/16 to 7/25, and from 7/16 to 8/2. Lastly, the older, high functioning males spent more time in MS compared to the younger, high functioning males. Overall, these results extend the previous work examining motor behaviors in physical education for young children with ASD (Fittipaldi-Wert, 2007) and adolescents with ASD (Lisboa, Butterfield, Reif, & McIntire, 1995). This study provides additional evidence that children and adolescents with ASD may achieve consistently high levels of motor appropriate and reduce inappropriate behaviors in PE or adapted sport contexts. However, it is necessary that interventions employ highly individualized, skill-based programming implemented by well-trained staff, and employ behavioral supports.

Taken together, this program of research is novel and represent important contributions to the adapted sports literature in several ways. First, we demonstrate that across a broad age range of participants (children, adolescents, adults) with ASD and other disabilities are able to significantly improve their tennis skills with a low dose of practice (~8 sessions). Second, we created and measured the efficacy of visual and behavioral supports that enable participants across the full spectrum of abilities to access the adapted tennis curriculum and maintain high levels of motor appropriate behaviors. Lastly, going beyond our measure of motor skills, we also quantified the impact of the adapted tennis program on physical activity levels and behavior in

children and adolescents with ASD. Few studies have examined the impact of adapted sports programs from a comprehensive perspective (i.e., beyond measuring motor skills). The results of this program of research help to provide guidance for physical educators, coaches, parents, and program directors to meet the needs of individuals with ASD and other disabilities. The evidence-based practices employed here may be used to optimize the outcomes of adapted sport programs on motor skills, physical activity levels, and adaptive behavior.

Chapter 2. Improvements in tennis skills in adults with developmental and intellectual disabilities following an 8-week adapted tennis program.

Introduction

The prevalence of developmental disabilities, including Autism Spectrum Disorder (ASD), Intellectual Disability (ID), and other developmental delays, has grown from 5.7% in 2014 to 6.99% in 2016 (Zablotsky, Black, & Blumberg, 2017). Individuals with developmental disabilities experience disparities in both mental (Einfeld, Ellis, & Emerson, 2011; Emerson & Hatton, 2007; Platt, Keyes, McLaughlin, & Kaufman, 2018) and physical health (Havercamp & Scott, 2015; Rimmer, Yamaki, Lowry, Wang, & Vogel, 2010). Participation in adapted sports and physical activities offered as part of school curricula (i.e., adapted physical education) and in the community (for review see Ryan, Katsiyannis, Cadorette, Hodge, and Markham, 2013) may attenuate health disparities in this population. Indeed, participation in adapted sports, including Special Olympics, is associated with improved social functioning (Dinomais et al., 2010; McConkey, Dowling, Hassan, & Menke, 2013; Shapiro & Martin, 2010a), enhanced self-concept (Crawford, Burns, & Fernie, 2015; Shapiro & Martin, 2010b; Weiss, Diamond, Demark, & Lovald, 2003), improved fitness (Baran et al., 2013; Guidetti, Franciosi, Gallotta, Emerenziani, & Baldari, 2010; Wright & Cowden, 1986), and increased physical activity levels (Walsh et al., 2018). A recent review of outcomes specific to Special Olympics participation reported similar benefits on physical, psychological, and social domains (Tint, Thomson, & Weiss, 2017). However, few studies have measured changes in motor skill development resulting from participation in adapted sports and recreation.

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should result in improvements in fundamental and sport-specific motor skills, research quantifying these changes is surprisingly sparse and predominantly examines the impact of Special Olympics programs for children and adolescent athletes. For example, Favazza et al. (2013) examined the efficacy of the Special Olympics Young Athletes program (SOYA; 3x a week, 8 weeks), which teaches fundamental motor skills for sport participation, in young children with ID (ages 3-5 years). They found that children that participated in the SOYA showed a significant improvement in the Peabody Developmental Motor Scales and teacher reported gross motor skills, compared with young children with ID that did not participate in SOYA. In an older group of children (6th-8th-grade students), Castagno (2001) reported improved performance on the Special Olympics Basketball Skill Assessment Test following an 8-week program (1.5 hours of instruction, 3x a week) for Special Olympics athletes and their peer partners. Using a similar training structure (1.5 hours, 3x a week for 8 weeks), Baran et al. (2013) reported improvements in the Special Olympics Football (soccer) Skills Assessment in 12-15 year old Special Olympics athletes and their peer partners. In a study comparing participation across different sports (basketball, swimming, and adapted physical activity) female athletes ages 13-17 years with ID improved in the performance of product-oriented skill assessments during completion over 8 months (Ninot, Bilard, Delignières, & Sokolowski, 2000). Together, these studies support the efficacy of adapted sports programs to develop motor skills in children and adolescents with and without developmental and intellectual disabilities. However, differences in dose of the interventions and a lack of process-oriented measures may limit the generalizability of these results.

To date, a handful of studies have examined improvements in motor skills resulting from adapted sports participation in adults with disabilities. All of these studies examined the effects

of competitive Special Olympics programs and used the product-oriented skill assessment tests provided by Special Olympics. For example, Chen, Ryuh, Fang, Lee, and Kim (2019) reported improvements in the performance of the Special Olympics Football (soccer) Skills Assessment in a broader age range (ages 12-25 years) with and without ID following a 15-week, twice a week adapted soccer program. Two studies have been conducted examining basketball ability in adults with ID. Guidetti, Franciosi, Emerenziani, Gallotta, and Baldari (2009) quantified changes in the performance of the Special Olympics Basketball Skill Assessment Test following a 4-month (4 hours weekly) training program in adults ages 21-43 years with ID. They reported significant improvements from pre- to post-training in fundamental basketball skills in all athletes. Interestingly, the authors also reported that level of impairment (i.e., mild, moderate, severe, profound) influenced the degree of improvement in basketball skills; those with mild or moderate impairments exhibited the most significant improvements in skills compared with those with severe or profound impairments. In a follow-up study, Baldari et al. (2009) examined the effects of a 6-month (4 hour weekly) basketball and strength and conditioning program in adults ages 19-42 years with ID. Similar results were observed; all athletes improved performance in the Special Olympics Basketball Skill Assessment Test from pre- to post-training and the degree of skill improvement was related to the degree of impairment (i.e., mild, moderate, severe, profound intellectual disabilities). Collectively, these studies provide preliminary evidence that complete adapted sport training improves motor skills in adults with ID, but that individual factors such as level of function influence skill improvement.

Many knowledge gaps remain regarding the changes in motor skills resulting from adapted sports programs for adults with disabilities. For example, what are the changes in process-oriented skill development? Can shorter duration programs result in similar

improvements as those observed previously (i.e., 3-6 month long programs)? Do adapted sports programs confer similar improvements for individuals with other developmental disabilities? Lastly, would similar improvements result from programs aimed at training new sports skills (i.e., developmental programs vs. competitive program)?

To address these knowledge gaps, the purpose of this study was to quantify changes in tennis skills and dose of practice in adults with ASD, ID, and Down Syndrome (DS) following an 8-week adapted tennis program. Unlike traditional team sports (e.g., soccer, basketball) or individual sports (e.g., swimming, gymnastics), tennis and similar racquet sports provide unique opportunities for athletes to develop motor skills at individual rates, while still participating in a social or team environment. This type of training environment is ideal for individuals across a broad age range and varying levels of functional ability (i.e., within and between disability groups). To date, no studies have examined changes in tennis skill development and dose of practice during an adapted tennis program in adults with various developmental disabilities. Importantly, given the heterogeneity of this population, we wanted to investigate the impact of age, disability type, and functional ability on improvements in tennis skills and practice dose. These individual factors are relevant for determining if this adapted tennis intervention is appropriate and scalable for different populations of individuals with disabilities.

Methods

Participants

All methods were approved by the Institutional Review Board (IRB) at Auburn University, and consent forms were obtained from participants' parents/guardians. Participants were recruited from two community programs for adults with developmental and intellectual disabilities. Data were collected from 27 participants (Female n=9, Male n=18) ages 19-35 years

(mean age = 24.70 years, standard deviation = 4.35 years) with the following disabilities: ASD (n = 10), DS (n = 7), and ID (n = 10). The details for each participant is provided in Table 1.

Table 1. Participants details. DS, Down Syndrome; ID, Intellectual Disability; ASD, Autism Spectrum Disorder; WHO-DAS, WHO Disability Assessment Schedule; CARS2-ST, Childhood Autism Rating Scale Second Edition.

ID	Gender	Age	Disability	WHO-DAS Summary Score	WHO-DAS Level of Function	CARS2-ST	CARS2-ST Autism Severity Category
TEN001	Male	26	DS	22.92	High		
TEN002	Male	23	ID	37.5	Middle		
TEN003	Female	24	DS	62.5	Middle		
TEN004	Female	24	ID	20.83	High		
TEN005	Male	23	ASD	41.66	Middle	31.5	Mild-to-Moderate
TEN006	Female	25	DS	27.08	High		
TEN007	Male	26	ASD	66.67	Low	49.5	Moderate-to-Severe
TEN008	Female	21	DS	56.25	Middle		
TEN009	Female	26	ASD	68.75	Low	48.5	Moderate-to-Severe
TEN010	Female	28	ID	39.58	High		
TEN011	Female	24	DS	29.17	High		
TEN012	Male	19	ID	27.08	High		
TEN013	Male	25	ASD	6.25	High	14.5	Minimal-to-No Symptoms
TEN014	Male	19	ID	60.41	Middle		
TEN015	Male	19	ID	68.75	Middle		
TEN016	Male	20	DS	22.91	High		
TEN017	Male	22	ASD	89.58	Low	48.5	Moderate-to-Severe
TEN018	Male	21	ASD	43.75	High	28	Mild-to-Moderate
TEN019	Male	21	DS	68.75	Middle		
TEN020	Female	24	ID	31.25	High		
TEN021	Male	23	ID	79.16	Low		
TEN022	Male	24	ID	10.41	High		
TEN023	Male	26	ASD	29.16	High	26.5	Minimal-to-No Symptoms
TEN024	Female	32	ASD	25	High	24	Minimal-to-No Symptoms
TEN025	Male	33	ASD	35.41	High	29.5	Mild-to-Moderate
TEN026	Male	35	ID	8.33	High		
TEN027	Male	34	ASD	62.5	Middle	31.5	Mild-to-Moderate

Parents/guardians completed the 12-item instrument World Health Organization Disability Assessment Schedule (WHO-DAS 2.0) to determine the participants' level of functioning. Each item is scored from 0 (no difficulty) to 4 (extreme difficulty, cannot do); scores were converted to a summary score that ranges from 0 (no disability) – 100 (full disability). The range of WHO-DAS summary scores for the participants in the program was 6.3-89.6 (mean = 42.28, standard deviation = 22.45). The WHO-DAS score and level of function based on terciles (low, middle, high) is presented in Table 1.

For participants with ASD (n=10), the Childhood Autism Rating Scale Second Edition (CARS2-ST) was completed by two researchers (Schopler, 2010). The average score and the Autism Severity Category for each participant with ASD are reported in Table 2.1. The range of CARS2-ST scores for the participants with ASD 14.5-49.5 (mean = 33.20, standard deviation = 11.83). Three of the 10 participants were classified as Minimal-to-No Symptoms, four were classified as Mild-to-Moderate, and three were classified as Moderate-to-Severe.

Program

An adapted physical educator and tennis professional oversaw the adapted tennis program and training of all staff. Undergraduate students were trained three weeks prior intervention on how to assist participants with instructions and how to identify additional behavioral supports (e.g., provided feedback, modeled skills, encouraged participation). During the practice of each skill, participants worked one to one with an undergraduate student who was available to provide additional training and support specific to tennis skills before, during, and after the sessions. Additional staff with experience teaching motor skills to individuals with disabilities were available during the sessions to provide additional support during the program.

The adapted tennis program was held twice a week for eight weeks (~1 hour per session). One session was taught on the tennis courts at the School of Kinesiology at Auburn University. Due to limitations of participants' transportation, the second session of the week was taught indoors at the community program facility; during this session, participants worked on racquet skills. A visual schedule was provided for each participant, and at the beginning of each session, the participants checked their schedule for the day. The on-court sessions schedule included: group warm-up (~5 minutes), volleys (~10 minutes), forehands (~10 minutes), backhands (~10 minutes), serves (~10 minutes), and a group game (~5 minutes). This schedule progressed from easier skills to more difficult skills and helped participants received consistent training and practice for each skill. A visual schedule was provided for each participant to help them transition between each skill.

The indoor sessions at the community program facility followed a similar schedule with an emphasis on eye-hand coordination and racquet skills. During the indoor sessions, participants were provided with video modeling on each of the tennis skills. Video modeling provided by IKKOS technology ("CopyMe" app) was used as supplemental support. A tennis professional served as the video model for each skill. The videos included an introduction with a breakdown of each skill identifying key components and verbal cues.

Data Collection

Pre- and post-test tennis skill assessments (process-oriented assessment) were conducted two weeks before and after the 8-week program (Figure 16). The assessment evaluated ten shots for the forehand and backhand. Each shot was scored based on the presence or absence (0 or 1) of the following five cues: ready position (facing the net), turn sideways, racquet back, swing forward, follow-through. The total for each shot was computed and averaged across the ten shots

(range 0 – 5). Note: based on pilot testing with adults with disabilities, nearly all of the participants were able to complete the volley as this is a very simple skill, while none of the participants were able to complete the serve as this is a very complex skill. Given concerns about ceiling and floor effects in the assessment as well as the length of time needed to complete the pre- and post-test skill assessments, the volley and serve were not evaluated.

The assessments were live-coded by one of the primary researchers in the study. In addition, a division I tennis player familiar with the process assessment and was blind to the participants, research question, and date of testing coded the assessments off-line from videos of the testing. The inter-rater reliability for the forehand from pre-test was 0.91, backhand from pre-test was 0.96, and forehand and backhand from post-test was 0.98 for both.

Forehand and Backhand Tennis Skills Assessment

Participant ID:_____ Date:_____

Instructions: Participants are going to perform 5 forehand trials, and 5 backhand trials. Each trial has 5 cues participants will be evaluated. If participant perform the cue a "YES" will be checked. If participant did not perform the cue a "NO" will be checked.

Trial 1

Forehand			Backhand		
Ready Position	YES_____	NO_____	Ready Position	YES_____	NO_____
Turn sideways	YES_____	NO_____	Turn sideways (Two hands)	YES_____	NO_____
Racquet back	YES_____	NO_____	Racquet back (Two hands)	YES_____	NO_____
Swing forward	YES_____	NO_____	Swing forward (Two hands)	YES_____	NO_____
Follow though	YES_____	NO_____	Follow though (Two hands)	YES_____	NO_____
Total YES_____ Total NO_____			Total YES_____ Total NO_____		

Figure 1. Example from the forehand and backhand process assessment. The full assessment for all 10 trials may be found at:

https://figshare.com/articles/Tennis_Assessment_Forehand_and_Backhand/7928678

A tennis sensor was housed within a silicone casing attached to the bottom of the participant's racquet (Head™ tennis sensor powered by ZEPP, Phoenix, Arizona, USA). The Head tennis sensor includes a triaxial accelerometer as well as a single-axis vibration sensor. Together, these sensors enable the recording of strokes when a ball has contacted the head of the

tennis racquet. The differentiation between shot types is based on a machine learning algorithm developed by Head to estimate rigid body motion based on shots performed by adult expert tennis players. The algorithm utilizes 10,000 shots as training data to differentiate between the different types of shots based on the acceleration and vibration profiles. Although the sensor provides information about the number of forehands, backhands, serves, and volleys the participant performed during the lesson (dose of practice) for the purpose of the present study only the number of forehand and backhand shots were examined, consistent with the process assessments.

To determine the accuracy of the sensors (i.e., correct labelling of each skill) for our population, we examined the labelling for 10 shots for forehand and 10 shots for the backhand for each participant. The percentage of shots that were correctly labelled provided an estimate of sensor accuracy. The percentage of shots incorrectly labelled was also computed (e.g., forehands labelled as volleys).

Statistical Analysis

All statistical analyses were conducted using MATLAB (Version 2017a, MathWorks™). Repeated measures ANOVA was used to assess the difference in the process scores for both forehand and backhand skills (i.e., pre-test to post-test). A model selection process was used to evaluate the effects of Time (pre-test, post-test), Age, Disability (ASD, DS, ID), WHO-DAS summary score, and any interactions between these factors; the most parsimonious model that accounted for the greatest variance in the dependent measure was selected as the final model. Follow-up t-tests were used to decompose any significant effects. To evaluate the difference in the number of strokes acquired by the sensors (i.e., practice dose), data from the first and last on-court sessions were compared. Again, repeated measures ANOVA was used to evaluate the

difference in the number of forehands and backhands. A model selection process was used to assess the effects of Time (Session 1, Session 8), Age, Disability (ASD, DS, ID) and WHO-DAS summary score, and any interactions between these factors. Follow-up t-tests were used to decompose any significant effects. The level of significance was set to $p < 0.05$ for all analyses.

Results

Figure 2 (top) depicts pre- and post-test process scores for the forehand. The individual data (left) and group means and standard deviations (right) are presented. The mean forehand process score for pre-test was 1.34 (standard deviation = 1.23), while the mean forehand process score for post-test was 3.77 (standard deviation = 0.82).

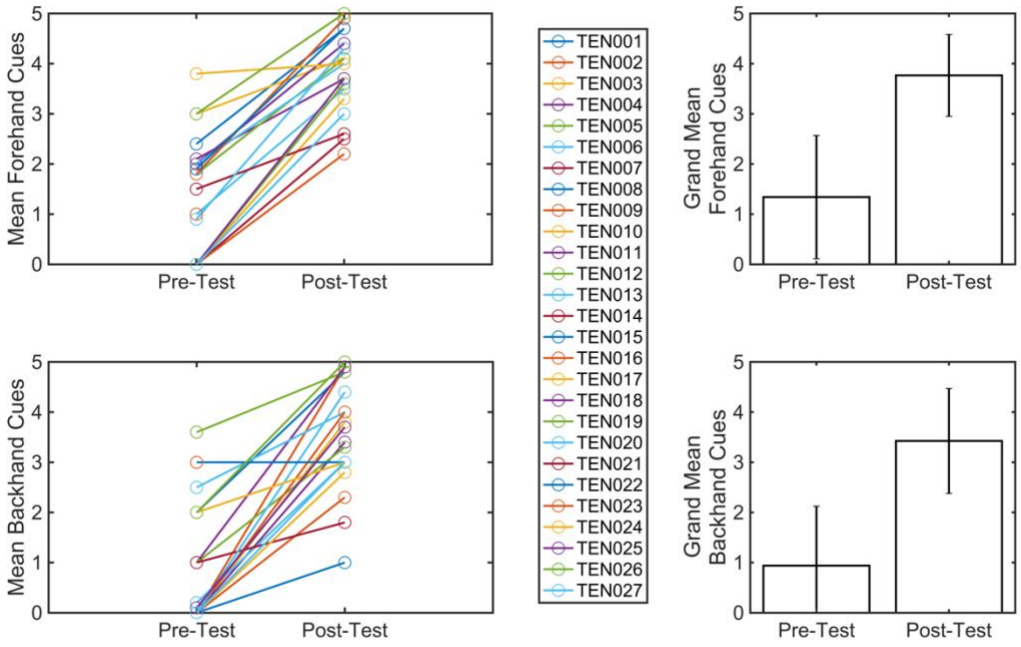

Figure 2. Pre-test and post-test process scores for each participant for the forehand (top, left), the means and standard deviations for pre-test and post-test process scores for the forehand (top, right), pre-test and post-test process scores for each participant for the backhand (bottom, left),

and the means and standard deviations for pre-test and post-test process scores for the backhand (bottom, right).

Model selection for the forehand process score revealed a significant main effect of Time ($F(1,22)=30.64$, $p < 0.001$) and a main effect of WHO-DAS total score ($F(1,22)=22.60$, $p < 0.001$). No significant effects for Age or Disability type or any interactions amongst any variables were observed ($p > 0.05$ for all). All individuals showed greater post-test process scores compared with pre-test process scores for the forehand. Individuals with lower WHO-DAS summary scores (i.e., higher function) showed greater forehand process scores. Figure 3 (left) depicts the pre-test and post-test scores for each individual by WHO-DAS score category (high, middle, low function) for the forehand cues (process scores). WHO-DAS summary scores were treated as a continuous variable in the statistical models but separated by terciles (high, middle, low function) for visualization purposes**.**

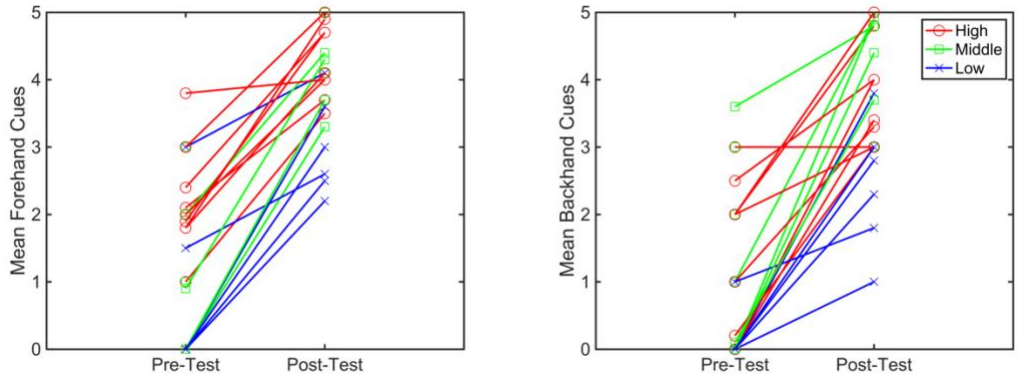

Figure 3. Pre-test and post-test scores for each participant by WHO-DAS summary score categories for the forehand (left) and backhand (right) cues. WHO-DAS summary score terciles are indicated as red circle (High < 28.13), green squares (Middle = 28.12 – 58.33), and blue X (Low > 58.33).

Figure 2 (bottom) depicts pre- and post-test process scores for the backhand. The individual data (left) and group means and standard deviations (right) are presented. The mean backhand process score for pre-test was 0.94 (standard deviation = 1.18), while the mean backhand process score for post-test was 3.43 (standard deviation = 1.05).

Similar to the findings from the forehand process score, model selection for the backhand process score revealed a significant main effect of Time ($F(1,22)=24.77$, $p < 0.001$) and a main effect of WHO-DAS summary score ($F(1,22)=18.64$, $p < 0.001$). No significant effects for Age or Disability type or any interactions amongst any variables were observed ($p > 0.05$ for all). All individuals showed greater post-test process scores compared with pre-test process scores for the backhand. Individuals with lower WHO-DAS summary scores (i.e., higher function) showed greater backhand process scores than those with higher WHO-DAS summary scores. Figure 3 (right) depicts the pre-test and post-test scores for each individual by WHO-DAS summary score category (high, middle, low function) for the backhand cues. WHO-DAS summary scores were treated as a continuous variable in the statistical models but separated by terciles (high, middle, low function) for visualization purposes.

The sensor validation revealed that mean accuracy and standard deviation of the sensor data for the forehand was 87.89% ± 11.34. On average, shots were incorrectly labelled volleys 11.05% and as backhands 1.05%. The mean accuracy and standard deviation for the backhand was 68.42% ± 38.48. On average, shots were incorrectly labelled volleys 8.42% and as forehands 23.16%. None of the forehand or backhand shots were incorrectly labelled as serves.

The differences in the sensor data (dose of practice), data from Session 1 and Session 8 were examined for the forehand and backhand (Figure 4). The mean number of forehand shots for pre-test was 64 (standard deviation = 32.92), while the mean number of forehand shots for

post-test was 84.72 (standard deviation = 39.80). A supplementary figure depicting the forehand and backhand shots for all session is available at https://figshare.com/articles/Supplementary_Forehand_and_Backhand_AllShots_AllDays/9823976.

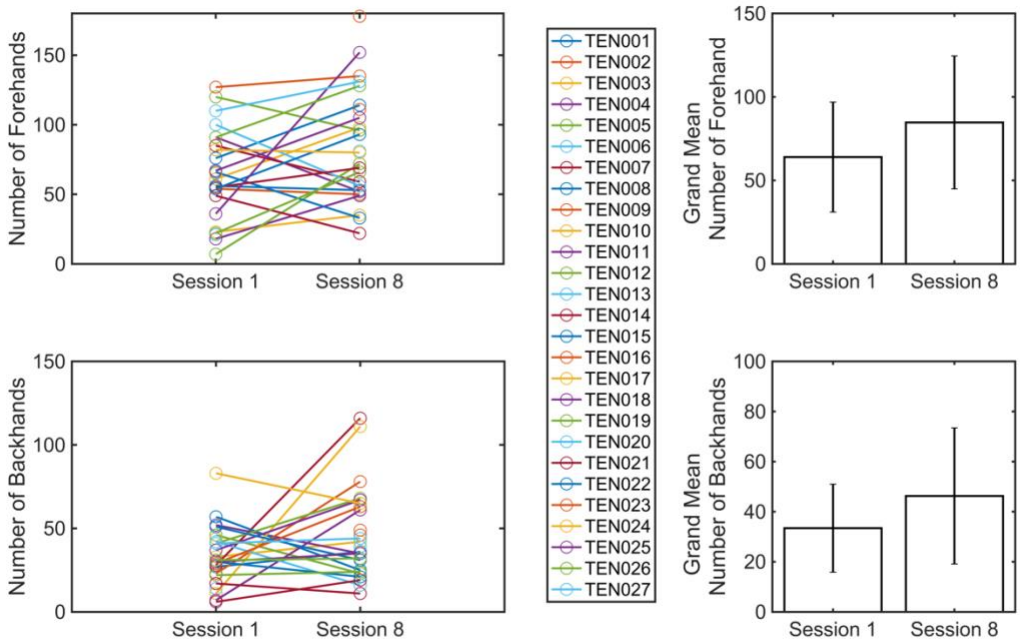

Figure 4. Number of forehands for Session 1 and Session 8 each participant (top, left), the means and standard deviations for Session 1 and Session 8 for the forehand (top, right), number of backhands for Session 1 and Session 8 each participant (bottom, left), the means and standard deviations for session 1 and session 8 for the backhand (bottom, right), Note: participants with missing data for Session 1 or Session 8 are indicated as circles without connecting lines.

Model selection for the number of forehand shots revealed a significant main effect of Age ($F(1,20)=9.31$, $p < 0.01$) and a main effect of Disability ($F(2,19)=4.11$, $p < 0.05$). No significant effects for WHO-DAS, Time, or any interactions amongst any variables were

observed ($p > 0.05$ for all). Older participants showed a significantly higher number of shots in the last session compared to younger individuals. Follow-up T-Tests comparing the three disability groups did not reveal statistically significant differences ($p > 0.05$ for all), although individuals with ASD tended to have more forehand shots than individuals with intellectual disabilities ($t(18)=1.87$, $p = 0.08$). Figure 5 depicts the number of forehand shots for Session 1 and Session 8 for each individual by Age category (left) and Disability (right). Age was treated as a continuous variable in the statistical models but separated by terciles (youngest, middle, oldest) for visualization purposes.

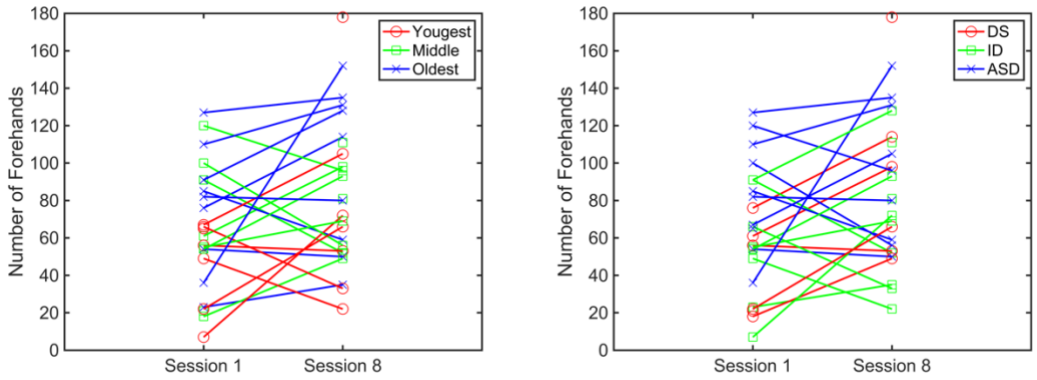

Figure 5. Number of forehand shots for Session 1 and Session 8 for each participant by Age (left). Youngest = < 23 years, Middle = 23-25.5 years, Oldest >25.5 years. Number of forehand shots for Session 1 and Session 8 by Disability (right). Red Circle = Down Syndrome, Green Squares= Intellectual Disabilities, Blue X = Autism Spectrum Disorder.

The mean number of backhand shots for pre-test was 33.42 (standard deviation = 17.57), while the mean number of backhand shots for post-test was 46.28 (standard deviation = 27.17). Model selection for the number of backhand shots did not reveal significant main effects or interactions amongst any variables ($p > 0.05$ for all).

In addition, inaccuracies in the labeling for the validation were not correlated with the participant's skill level based on the pre- and post-test process assessments ($p > 0.05$ for both). In other words, the sensor was not more accurate in differentiating shots for a participant with high skill compared to a participant with low skill. Differences in the number of forehands or backhands shots from Day 1 to Day 8 (dose) were not correlated with differences in the process scores for the forehand or backhand from pre-test to post-test ($p > 0.05$ for both). Total number of forehand or backhand across all sessions were not correlated with differences in the process scores for the forehand or backhand from pre-test to post-test ($p > 0.05$ for both).

Discussion

This was the first study to quantify differences in tennis skills and dose of practice in adults with various developmental or intellectual disabilities participating in an 8-week adapted tennis program. The overall changes in tennis skill process scores suggest that regardless of age, disability, or level of function, all participants improved the forehand and backhand during the 8-week intervention. Level of function, but not age or disability type, was associated with changes in forehand and backhand process scores. The number of forehand shots performed during the adapted tennis program did not change across time. The number of forehand shots was associated with age and disability, but not level of function. The number of backhand shots (dose) was not associated with age, disability, or level of function. The number of forehand or backhand shots (dose) was not associated with changes in forehand or backhand process scores, respectively. Taken together, these results suggest that the quality of the practice (and not simply the dose) may be important to consider in future studies examining the efficacy of adapted sports programs on motor skill development in adults with disabilities.

This study included adults with various disabilities (i.e., ASD, DS, and ID) with a broad range of level of functioning. In contrast, previous studies examining adapted sport participation on motor outcomes have focused on individuals with ID, which may because most studies examined programs associated with Special Olympics, whose inclusion is based on ID. The results here suggest that individuals with ASD, DS, and ID benefit from the adapted tennis program. However, individual differences in skill and practice were observed across disabilities. These results suggest that adapted sports programs that include a broader range of participants with various disabilities should consider individual differences in behavioral or functional needs; some participants may require additional support during practice and pre-post testing (see below regarding behavioral and peer supports implemented).

Level of function, but not age or disability type, was associated with changes in forehand and backhand process scores. However, the lack of interaction between level of function and time, suggests that individuals with higher function have better skills throughout the program, compared to those who lower functioning. These results differ from those reported by Guidetti et al. (2009) and Baldari et al. (2009), who found that level of function was associated with *changes* in skill following a 4- or 6- month adapted basketball program, respectively (i.e., function x time interaction). It is possible that the differences observed may be due to the greater number of participants in the current study with a higher level of function (mild or moderate impairment) compared with previous studies. Another explanation for the discrepancy may be differences in the length of the interventions. The current intervention was 8-weeks long, and it is possible that differences in the degree of skill development may emerge across different levels of function over a more extended period of training.

With respect to the dose of practice (i.e., number of shots), the present results suggest that older participants performed significantly more forehand shots, compared with younger individuals. Individuals with ASD tended to have more forehand shots compared with those with ID. However, no main effect of Time, or Age x Time or Disability x Time interactions were observed. Moreover, differences in the number of forehand shots from Session 1 to 8 or the total number of forehand shots (for all sessions) did not predict changes in forehand skill (process scores). These results suggest that the number of forehand shots alone does not influence the process measures of forehand skill. There are several potential explanations for these findings. The number of shots does not necessarily reflect the dose of practice because the number of shots was limited by the time allotted during the practice for each skill (i.e., 10 minutes per skill). If participants were able to practice the forehand for a self-selected period of time, greater variability of dose may be evident and related to forehand process scores. It is worthwhile to note that the practice schedule was purposefully limited and required the practice of all skills to prevent participants from only practicing the easier skills (e.g., volleys and forehands). Another explanation is that it is necessary to take time during the session to provide feedback on the performance of the skill, which would result in a lower number of shots performed during the 10 minutes of practice. Therefore, although the number of shots is reduced, the quality of the practice is increased (but would not be measurable using the tennis racquet sensors). Evaluation of the sessions via live or video coding of participant behaviors as well as coach/peer feedback and demonstrations would be necessary to evaluate the quality of the practice session.

In comparison to other studies examining changes in adapted sport skills in adults with disabilities, the current study observed significant improvements in a fewer number of sessions. For example, the adapted soccer program examined by Chen et al. (2019) consisted of twice a

week training (50 minutes per session) for 15-weeks. The adapted basketball programs examined by Guidetti et al. (2009) and Baldari et al. (2009) consisted of a 4-month (4 hour weekly) training program and a 6-month (4 hour weekly) basketball and strength and conditioning program, respectively. In contrast, the current intervention consisted of 8-weeks of training held twice a week for 1 hour. It is possible that changes in forehand and backhand process scores observed during this relatively short program may be due to the structure of the adapted tennis program, or perhaps the fact that tennis provides participants the opportunity to hit more shots comparing to other sports (e.g., soccer, or basketball). The schedule of the program enabled dedicated practice of the skills (volley, forehand, backhand, serve) for 10 minutes each. Visual supports for each skill were provided for all participants (i.e., schedule, and task cards of each skill with cues). Coaches were available to provide feedback and modify tasks to the needs of the participants. In addition, the program provided a 1 to 1 ratio of participant to undergraduate student (peer buddy), who provided feedback, modeled skills, and provided encouragement during the sessions. This type of peer-assisted learning may be useful in physical education and sports programs to improve motor skills as well as promote psychosocial outcomes (Jenkinson, Naughton, & Benson, 2013). It is possible that significant improvements over a short duration can be observed with other adapted sport programs with a similar structure.

Another potential explanation for the significant improvements in tennis skills observed during this short intervention is the assessments and level of skills examined. The assessments and training program were developed to assess the development of fundamental aspects of tennis skills and provide instruction for novice tennis players. In comparison, the assessment (Tennis Rating Sheet) and program guide for the Special Olympics tennis ("Special Olympics Tennis Coaching Guide," 2014) is appropriate for more experienced tennis players. For example, even if

a participant exhibited all cues for the forehand process assessment for all ten shots evaluated (i.e., process score of 5), the Special Olympics Rating Sheet would be necessary to characterize the consistency, strength, depth, pace, and ability to rally with the forehand shot. It is unlikely that a participant with a process score less than five on the present assessment, would be able to perform the forehand with sufficient consistency, strength, depth, and pace necessary to rally. Further training, consistent with the dose observed with previous Special Olympics programs (e.g., higher weekly dose and longer program duration) would be necessary for athletes to increase the level of each skill evaluated by the Special Olympics Rating Sheet. Therefore, the present program and assessments would be beneficial as a first step towards participation in the Special Olympics or other competitive adapted tennis programs.

Limitations

One limitation to the study is that the process assessments were live-coded by one of the primary researchers in the study, who was not blind to the research questions, participants, or test date. Therefore, there may be bias in the process assessments. However, the off-line coding completed by a secondary coder with expertise in playing and coaching tennis, but was blind to the research question, participants, and test date provided evidence of high inter-rater reliability. This suggests that the present results may not be affected by bias.

There are important limitations the use of the sensors to estimate dose of practice. First, the original sensor validation by Head was based on a professional model. Therefore, relying on the raw output from the sensors may lead to inaccuracies in the labeling of each shot and the total number of shots. Validation of the sensors for the population of interest using a similar methodology employed here is recommended. Data from the validation of this population suggests that the sensors were moderately accurate for the forehand (87.89%) and backhand

(68.42%). This the validation (i.e., recording the sensor data after each skill) was only conducted during the assessments of the forehand and backhand and not during the practice session. Therefore, in the present study, we are unable to quantify inaccuracies in the skill labelling during practice. It is possible that the total dose for the forehand during the practice was likely overestimated, while the total dose for the backhands was likely underestimated. In order to obtain a more accurate estimate of the dose of practice for each skill, the output from the sensor should be recorded/archived after each skill is practiced. In this way, any inaccuracies in the labelling of each shot can be determined and potentially corrected in the data analysis. Another limitation to the use of the sensors is that even if the stroke was correctly labelled, the sensor does not provide information about whether the stroke was performed "correctly" (i.e., exhibited the characteristics of the stroke measured by the process assessment or if the ball landed on the court). Future studies are needed to determine if any performance characteristics (i.e., process or product measurements) or other aspects of the practice are related to the output from the sensor data.

Conclusion and Future Directions

Overall, the adapted tennis program examined presently was effective in improving tennis skills in a short period of time across a broad age range, disability type, and level of function. Future studies are needed to replicate and extend this program. In addition to examining changes in forehand and backhand skills, process assessments for the volley, serve, and rally (i.e., back and forth play) would be useful to assess the range of fundamental tennis skills. With that being said, the serve and rally are challenging skills and 8-weeks of practice may not be sufficient for significant improvements in those skills. Video recording (or live coding) sessions are necessary to characterize the quality of practice sessions further. A longer

period of time may be needed to observe differences in age, disability, and level of function on long-term skill development (i.e., greater than eight weeks) and skill retention (following a period of no practice). Additional studies are needed to examine a broader age range of adults with disabilities (e.g., older than 35 years). The degree of improvement and dose of practice for older adults with disabilities resulting from this program may be different than those reported here. For example, older adults may require additional training session due to cognitive (e.g., memory impairments, reduced speed of processing, etc.) and physical limitations (e.g., arthritis, balance problems, visual impairments, etc.) to reap the same degree of benefit as younger adults. Lastly, additional studies are necessary to examine the effects of each of the different behavioral supports implemented in the present study (video models, visual schedule, peer support, etc.) and how these supports differ by level of function or disability category of the individual. These individual factors are relevant for determining if this adapted tennis intervention is appropriate and scalable for different populations of individuals with disabilities.

Chapter 3. Behavioral Supports to Increase Skill Learning, On-Task Behavior, and Enjoyment of an Adapted Tennis Program (ACEing Autism) for Children and Adolescents with Autism Spectrum Disorder

With the growing prevalence of children diagnosed with Autism Spectrum Disorder (ASD; Christensen et al., 2016), interventions are necessary to increase participation in activities of daily living including physical activity and sports. Although ASD is defined as a social communication disorder (American Psychiatric Association, 2013), movement difficulties have been well-documented in this population (Fournier, Hass, Naik, Lodha, & Cauraugh, 2010). In addition to movement problems, children with ASD face additional barriers to participating in physical activities and sports. For example, barriers reported by parents include a lack of motivation or interest in physical activity, lack of time to participate, movement impairments, increased fatigue, lack of community programs, and inadequate training of staff (Obrusnikova & Cavalier, 2010). Compared to typically developing peers, fewer adolescents with ASD report enjoying team sports, physical education, or physical activities; while more adolescents with ASD perceived that physical activities were too difficult to learn (Stanish et al., 2015).

Physical educators employ equipment modifications (e.g., different size of balls, racquets, and nets), rule modifications (e.g., changing boundary lines, scoring systems), and various types of instructions (e.g., verbal, modeling, or pictures) to increase participation of children with ASD (Block, 2016; Grenier, 2014; Lavay, French, & Henderson, 2016; Lieberman & Houston-Wilson, 2018). Yet, a primary concern raised by adapted physical educators is the need for additional strategies to reduce behavioral difficulties, particularly for individuals requiring substantial support (Healy, Judge, Block, & Kwon, 2016). The present paper describes the development and implementation of supplemental behavioral strategies used during an after-

school adapted tennis program for children and adolescents with ASD (ACEing Autism). The goal of the paper is to describe the ACEing Autism program and to provide concrete examples of how these behavioral strategies supplement the standard curriculum to increase motor skill learning, on-task behaviors, and enjoyment.

Figure 6. Executive director Richard Spurling coaching a young player (left top). Director of program operations Justin Belisario (right top) assisting a young player with the volley. Group game (bottom).

ACEing Autism

ACEing Autism (www.aceingautism.org) is a national non-profit organization whose mission is to use tennis as a vehicle to enhance the lives of children and families with ASD across the spectrum. The program enables children with ASD to be physically active and socially-engaged during adapted tennis lessons. Since its inception in 2008, the program has grown to 70 sites throughout the US and serves over 1,300 children between the ages of 5-18 years. ACEing Autism is currently developing a program for adults with ASD ages 19 and older. Tennis coaches, parents, ABA therapists, high school or college students, and physical educators currently serve as local program (site) directors and oversee program management and logistics (e.g., training and managing volunteers, recruitment, providing lessons, etc.). In addition, this program could be easily implemented by parks and recreation, therapeutic recreation, or adapted sports professionals. There are two standard delivery methods employed. In the traditional model, weekly clinics (once a week) are offered at a tennis facility for a total of 6 weeks (1 clinic per week). In the school-based model, clinics are offered during the physical education class or recreation time and the schedule of clinics is based on the school's programming (e.g., during twice weekly physical education classes during the semester).

ACEing Autism provides a standard adapted tennis curriculum, visual supports (e.g., visual schedule), equipment (i.e., mini nets, racquets, different balls, hoppers, poly spots, place markers, tennis tees), t-shirts for participants and staff members, and training materials for coaches and volunteers. The standard curriculum employs the following structured schedule: group warm-up, hand-eye coordination, racquet skills, volleys, groundstrokes (forehands/backhands), games, and a group cheer. The curriculum was developed to build confidence using a progression from the easiest skills to the more difficult skills, and the

curriculum enables local program directors to modify the lesson plan to the abilities of each child. A manual and videos are provided to train local program staff with examples for each task. The manual also includes set-up diagrams and descriptions of each task. A volunteer manual is provided to train volunteers to work with individuals with ASD (e.g., information about ASD, engaging/interacting with participants, accommodating for communication differences, etc.). Generally, volunteers have experience playing tennis, though this is not a prerequisite. During the sessions, the coaches use the visual schedule to orient the participants to each task (Figure 2); coaches also have a simplified version on a lanyard. The national program staff provides 1.5-hour in-person training prior to the first session. To ensure program quality and consistency across the local programs, the ACEing Autism national program has two Board Certified Behavioral Analysts (BCBAs) on staff that evaluate each program based on a rubric (program management, training, professionalism, interaction with participants/parents, implementation of the curriculum, etc.). The BCBAs may provide additional recommendations to address participant needs for those with lower levels of cognition, behavior, and communication. In the traditional delivery model, the participant costs average around $10 per clinic, which covers the rental of equipment and fee for the local program director. Local fundraising and grants aimed at increasing adapted programming for individuals with disabilities (e.g., Autism Speaks, NextForAutism) could be used to defray the costs for facilities and additional staff (coaches or ABA therapists).

At the end of each session, ACEing Autism sends a program evaluation for parents to complete that asks about perceptions of the program, improvements in tennis, general motor skills, social skills, attention, language, behavioral regulation, confidence, sleep, diet/eating, fitness, physical activity levels, and interest in sports/physical activity. The results from the 2018

program evaluation (not published) suggest that children with ASD show broad improvements in confidence, social skills, and motor skills (including tennis-specific skills) after participation in the program. Parents also reported positive changes in language, behavioral regulation, sleep, diet, and fitness. For more information about the program evaluation questionnaire for parents, please contact ACEing Autism (www.aceingautism.org).

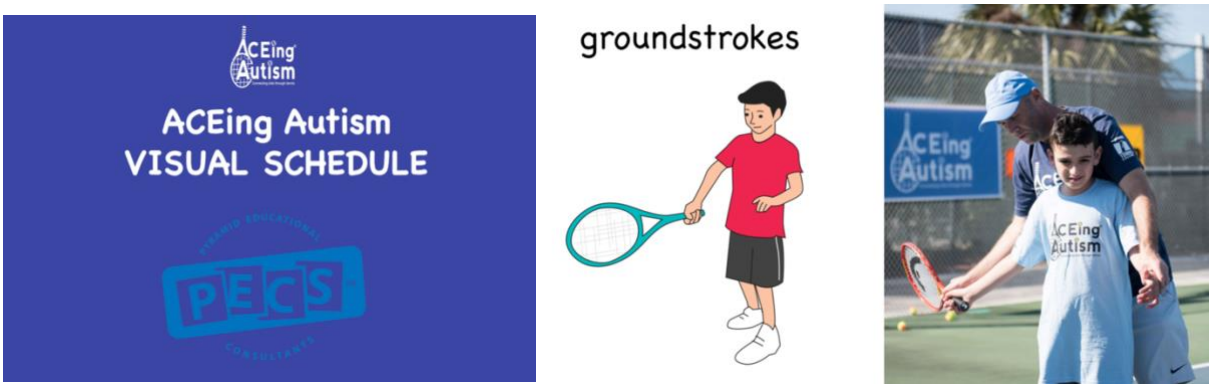

Figure 7. The ACEing Autism visual schedule for groundstrokes

Additional Behavioral Supports

Auburn University launched an ACEing Autism program during summer 2018 with a total of 22 participants ages 8- to 18-years across the full spectrum. The modifications made to the standard ACEing Autism program employed to accommodate the range of participants are described here. First, the delivery model was a variation of the school-based program; participants completed twice weekly clinics for four weeks (8 clinics total) over the summer. Make-up sessions were available to ensure all participants completed 8 clinics. The program for participants ages 8-12 years took place from 4-5pm and the program for participants ages 8-18 years took place from 5:15-6:15pm. Second, each participant also completed a pre-test skill assessment for the volley, forehand, and backhand to determine the participant's skill level. The pre-test assessment was used for ability grouping (i.e., courts were assigned based on similar skill levels) and was provided to the participant's volunteer in preparation for the first clinic.

Third, the volunteers were undergraduate students in Exercise Science, who completed a two-week training on professionalism, details about the ACEing Autism program (volunteer manual), information about ASD, facilitating on-task behaviors, and instructional methods for each tennis skill (i.e., verbal and visual cues and appropriate feedback). Each volunteer was matched to each program participant and worked with that participant for all 8 clinics. During training they were provided with information about their participant and how to specifically motivate their participant to be successful during the program. Each volunteer completed the "Protecting Children: Identifying and Reporting Sexual Misconduct" offered online through United Educators (https://www.edurisksolutions.org/learn-to-protect-children/) required of all Auburn University employees or students participating in programs with minors; background checks are required for all ACEing Autism volunteers and staff over the age of 18.

There were no limitations regarding level of function, cognitive ability, communication of participants, or previous experience with tennis. During the registration process, parents provided information about their child's diagnosis, expressive and receptive communication, participation in recreational activities, experience with tennis, education (e.g., public school, private school, mainstream, etc.), therapies, additional information regarding recommended strategies/supports, program goals, and family demographics. This information was used to prepare the appropriate behavioral supports for the pre-test tennis skills assessment and during the program. Based on the parent information, participant's age, and the participant's performance and behavior during the pre-test tennis skill assessment, groups of 4 participants were assigned to each court. This grouping enabled participants with similar ages (8-12 year olds 13-18 year olds), tennis skills, and level of functioning to be placed together. Participants requiring substantial support (e.g., severe lack of communication skills, exhibit challenging

behaviors, low cognitive ability, etc.) were assigned to a court (group of 2-3 participants) and received oversight from two BCBAs in addition to volunteers and coaches.

In addition to the materials provided by ACEing Autism, additional behavioral supports were developed as a supplement to increase motor skill learning, on-task behaviors, and enjoyment for participants across the spectrum. These behavioral supports were based on best practices for inclusive physical education (Block, 2016; Grenier, Miller, & Black, 2017; Lieberman & Houston-Wilson, 2018) and recommendations specific to children with ASD (Grenier, 2014; Healy et al., 2016; Houston-Wilson & Lieberman, 2003; Lee & Haegele, 2016; Menear & Neumeier, 2015). The behavioral supports used to supplement the standard ACEing Autism program included: 1) a social story; 2) a checklist schedule for task completion; 3) video and picture models for each skill; 4) token system; and, 5) feedback about task completion using an iPad application. Table 2 provides a breakdown of the tasks completed during the session and the implementation of the supports. The use of each behavioral support was based on the needs of each participant (i.e., communication skills, behavioral challenges, cognitive ability), but the checklist, picture models, and feedback about task completion from the iPads were consistently used for all participants for all sessions. The social story, video models, and token system were added or removed based on the participant during the course of the program but were commonly used for those with more substantial behavioral needs. All parents attended an orientation session that provided additional program information, details about logistics, information about the behavioral supports, and recommendations for facilitating tennis skills between sessions. Although parents do not have a formal role in the program, they can facilitate program goals via the social story and visual supports for use at home. Parents are encouraged to use the time during the program as respite and to socialize with other parents.

Table 2. Lesson Plan – Behavior Strategies Implemented

Activity	Task/Learning Experience	Behavioral Supports
Instructor-led Warm-up (5-10 minutes)	1. Provide a routine and keep it simple. 2. Students will stand on the same spot, complete the same number of exercises, and work with the same buddy. 3. Have students stand on the baseline of the tennis court. 4. The students will perform stationary stretches followed by running, skipping, or sliding to the net and back to the baseline. 5. The instructor will lead the students through games that practice eye-hand coordination, such as: balancing the ball on the racquet while stationary or moving, pushing or pulling the ball with the racquet on the ground, bouncing the ball with the racquet into air, dribbling the ball with the racquet, bouncing the ball (or multiple balls) with a partner.	1. Review *social story* to students at the beginning of the lesson. 2. Review the visual schedule. 3. Provide students with an individual *checklist schedule* and encourage them to review the schedule prior to the beginning of the lesson. 4. Demonstrate each of the warm-up activities. 5. Upon completion, the student will check off the warm-up on the *checklist schedule*.
Volley (5-10 minutes)	1. Position a poly spot 2 feet from the net. 2. The grip is the same for the forehand and backhand volley. 3. Students are encouraged to hit 10 successful volleys without stopping. 4. As students improve, students can hit shots while rotating between two poly spots placed 5 feet apart (volleys on the move). **CUES: "Face the Net", "Racquet Up", "Contact with Ball", "No Backswing" and "Punch Forward"**	1. Review *video models* on iPad or view the breakdown of the volley using the *picture models*. 2. Focus on the first cue, "ready position". When the first cue is demonstrated moving to next cue ("racquet up"). 3. Use the *token system* to tally number of volleys over the net. 4. Review the Head iPad app for *feedback* on the total number of shots for the volley. Encourage the student to hit the same number of shots for the next skill. 5. Upon completion, the student will check off the volleys on the *checklists schedule*.
Forehand (5-10 minutes)	1. Position a poly spot on the service line. 2. Students should stand with their feet apart with the opposite shoulder (as the arm holding the racquet) facing the net.	Same process as volleys.

	3. The students should let the ball bounce and swing forehand groundstrokes from a stationary position. 4. Students are encouraged to hit 10 successful forehands without stopping. 5. As students improve, students can hit shots while rotating between two poly spots placed 5 feet apart (forehands on the move). **CUES: "Ready Position", "Turn Sideways", "Racquet Back", "Swing Forward", and "Follow Through"**	

Backhand (5-10 minutes)	1. Position a poly spot on the service line. 2. Students should stand with their feet apart with the same shoulder (as the arm holding the racquet) facing the net. 3. Students should let the ball bounce and swing backhand groundstrokes in a stationary position. 4. Allow students to hold the racquet with two hands. 5. Students are encouraged to hit 10 successful backhands without stopping. 6. As students improve, students can hit shots while rotating between two poly spots placed 5 feet apart (backhands on the move). **CUES: "Ready Position", "Turn Sideways", "Racquet Back", "Swing Forward", and "Follow Through"**	Same process as volleys.
Instructor-led Group Game (5-10 minutes)	1. All students will stand on a poly spot on the baseline of the tennis court. 2. The instructor teaches the names of each line on the tennis court and where they are located (baseline, service line, center line, doubles line, and singles line). 3. The instructor calls one line at a time and all the students have to run and stand on the line called.	1. Provide a picture of the court with all lines labelled. 2. Demonstrate each of the group game activities. 3. Upon completion, the student will check off the group game on the *checklist schedule*.

	4. The instructor can revisit some of the games from the warm-up (#5) but played in a group context.	

Social stories use a specific story format and provide children with ASD information about situations in which they may be involved and the appropriate way to respond in those situations (Gray, 2015). A social story should be written in first-person language and include a description of the behaviors participants are asked to perform throughout the lesson (Gray, 2015). Grenier (2014) provides recommendations on the development and implementation of social stories in physical education. Social stories increase skill learning (Mowling, Menear, Dennen, & Fittipaldi-Wert, 2018) and may decrease anxiety experienced by children with ASD (Grenier & Yeaton, 2011). A social story was developed to provide participants with information about the setting, schedule, goals, and tasks specific to the program at Auburn University (an excerpt is provided in Figure 8). The social story was reviewed by parents/instructors before the first lesson and was available for students if they needed to review the story at the beginning of and during each lesson. Access to the full social story is available at: https://figshare.com/articles/ACEing_Autism_Social_Story/7836962.

Figure 8. Excerpt from the social story developed for the ACEing Autism program in Auburn, AL.

A checklist schedule was used to augment the visual schedule provided by ACEing Autism. Consistent with the recommendations for best practices, the checklist schedule was used to orient students to the order of tasks, encourage task completion, and provide a preview of all tasks (Block, 2016; Fittipaldi-Wert & Mowling, 2009; Houston-Wilson & Lieberman, 2003). Each student had a checklist schedule and examined the schedule at the beginning of the lesson

(Figure 9). After the completion of each task/skill, a check mark was placed on the schedule to illustrate that the activity was completed, and the lesson moved to the next skill. The volunteers working with each participant were encouraged to ask questions to check for understanding (e.g., "What skill did you complete? What skill are you doing next?"). This process enabled the successful transition from one task to the next.

Figure 9. Checklist schedule

Modeling in the form of picture- and video-based systems allows students to view the correct behaviors in sequence in a standardized format and may be useful when teaching motor skills (Block, 2016; Grenier, 2014; Mechling & Swindle, 2012). Video modeling has been used to increase physical activity participation (Bassette, Kulwicki, Dieringer, Zoder-Martell, & Heneisen, 2018) and motor skill learning (Gies & Porretta, 2015; Mechling & Swindle, 2012; Obrusnikova & Rattigan, 2016). Video modeling of each tennis skill was provided via an iPad application (CopyMe, IKKOS™) that showed the instructor performing the skill (third-person perspective). The video models for each skill showed a tennis instructor (Loriane Favoretto) performing the skill in real time, a breakdown of the skill into its parts with simple verbal cues (prompts), and the tennis instructor performing the skill again in slow motion with repeated

presentation. The verbal cues were based on a task analysis of key components of the skill (e.g., for the forehand: “ready position”, “turn sideways with arms open”, “palm faces net”, “contact the ball in front of the body”, “follow-through to opposite shoulder”). Figure 10 shows a screenshot of one of the video models with the tennis instructor performing the forehand from two different angles. The participant can watch the skill videos during the clinics and in between clinics to focus on the relevant task parameters. Access to all video models is available through CopyMe (ACEing Autism).

Figure 10. Video modeling of forehand groundstroke from front view (top) and side view (bottom)

In addition to iPad-based video models, pictures from the videos with simple cues were provided on the courts next to the checklist schedules (Figure 11). The participant was able to examine

each task and with the assistance of a volunteer or coach would identify the next component of the skill to practice (e.g., “follow-through to opposite shoulder”). This sequential process, consistent with forward-chaining, enabled participants to focus on one cue at a time and eventually put all cues together to complete the skill (Block, 2016). All picture models are available at: https://figshare.com/articles/ACEing_Autism_Visual_Supports/7854992.

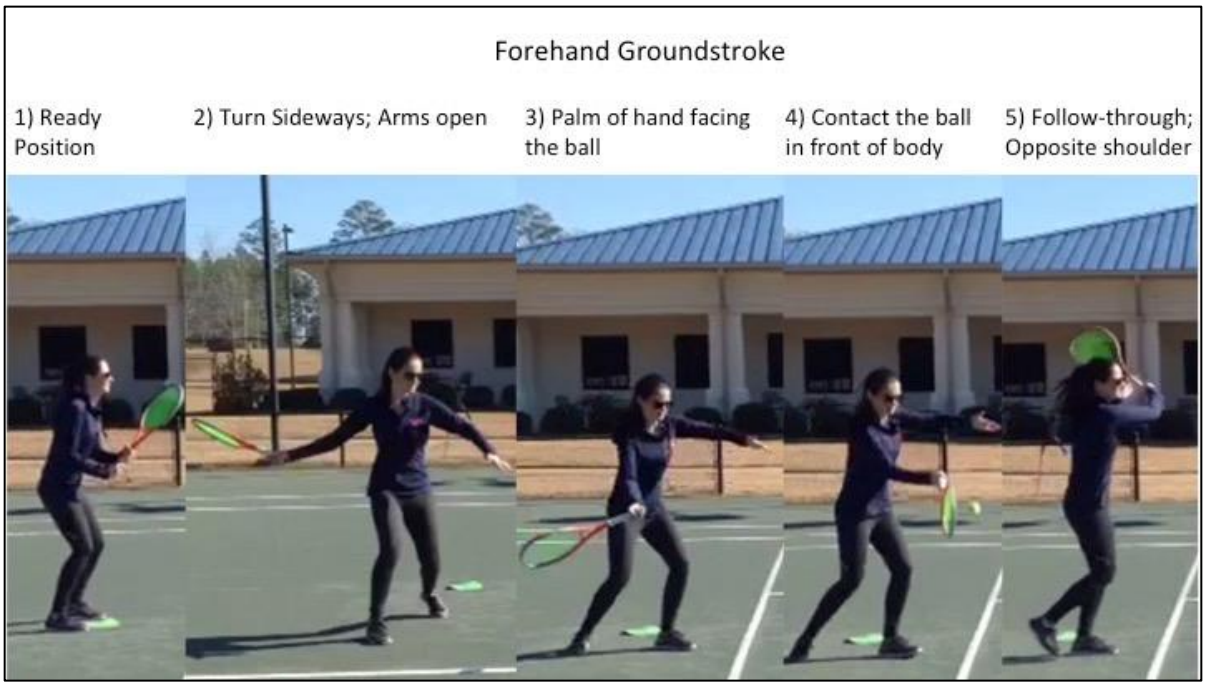

Figure 11. Picture model of forehand groundstroke with cues from the side view

A token system is a form of extrinsic motivation where the child receives a reward in exchange for performing the correct behavior and is an effective management strategy when working with children with ASD (Block, 2016; Lavay et al., 2016; Lieberman & Houston-Wilson, 2018; Matson & Boisjoli, 2009). This system should be simple, age-appropriate, used consistently, and provided after the student successfully demonstrates the appropriate behavior or completes a task correctly (Block, 2016; Lavay et al., 2016; Matson & Boisjoli, 2009). For the ACEing Autism program, a token system was created using pool noodles cut into disks that were

attached to the top of the net (Figure 12 The tokens were moved by volunteers or the participants across the net to encourage the participants to hit a specified number of shots (e.g., 1 token = 10 shots). Once participants achieved the specified number of tokens (e.g., 5 tokens), they were permitted to take a break or move on to the next task. Participants were encouraged to count the tokens with volunteers as a marker for the total number of shots and encouraged to acquire the same number of tokens (or more) for the following skill.

Figure 12. Token system

Lastly, feedback regarding the number and velocity of shots was provided by the Head tennis sensor attached to the bottom of the participant's racquet, which streamed data to the Head tennis sensor iPad app (Head™ tennis sensor powered by ZEPP, Phoenix, Arizona, USA; Figure 13). After completing each task, the participants could look at their data on the app. Participants could also look at data from the previous session and with help of the volunteers and coaches can set goals for the number and velocity of shots for the practice. This feedback is a form of extrinsic positive reinforcement that could be used in conjunction with or in substitution of the

token system. The incorporation of this form of feedback was based on studies suggesting that "gamification" can lead to increased motivation and engagement during skill learning in children with ASD (Malinverni et al., 2017).

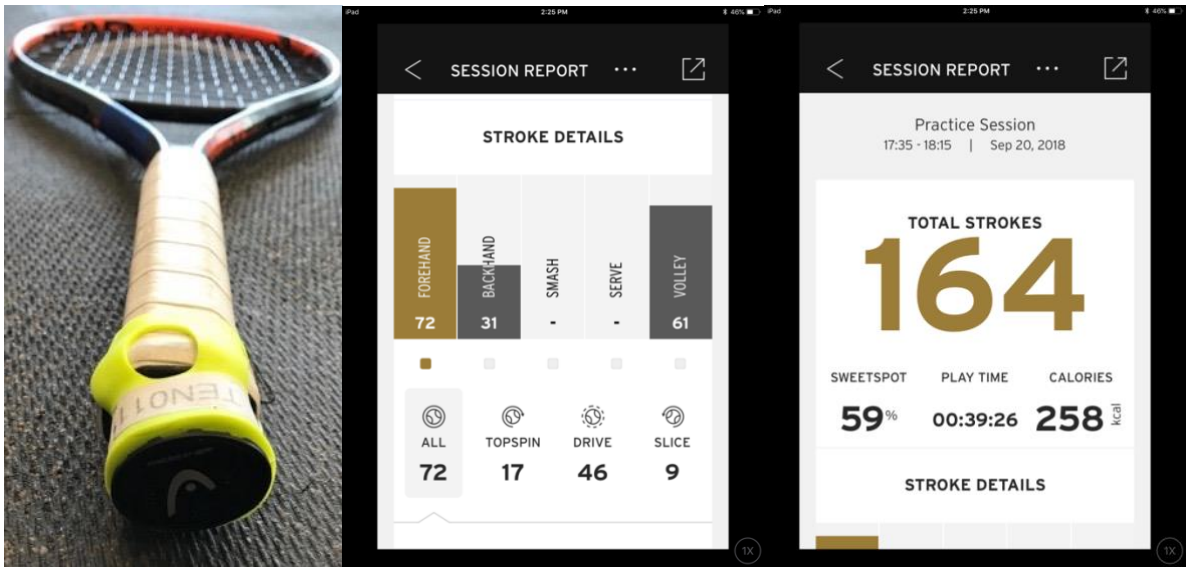

Figure 13. Head tennis sensor (left) and screenshot of feedback from Head Sensor iPad app (middle, right)

Example of Implementation – Requiring Very Substantial Support

Participant 1 was a 17-year-old male with ASD. He had good receptive communication (e.g., could follow simple verbal and visual instructions) and low-moderate cognitive abilities. He had minimal expressive communication (few words of intelligible speech), displayed signs of anxiety or distress before and during lessons, exhibited repetitive behaviors that increased with stress or frustration, had difficulty transitioning between tasks, and had trouble focusing during tasks. For this participant, all of the behavioral supports described above were implemented. The social story was read to Participant 1 by his parents before the start of the program and repeated before each clinic if Participant 1 exhibited anxiety. An iPad with the video models was provided to preview each skill. At the beginning of each practice, the visual schedule, checklist schedule,

and picture models were reviewed. Before initiating each task, Participant 1 was shown the pictures of each skill and provided with the relevant cue. The volunteer and ABA therapist working with Participant 1 would reiterate the target cue for each skill (e.g., "racquet back") during the practice and would provide congruent positive feedback to reinforce the cue (e.g., "great job bringing your racquet back"). The tokens were used to represent ten shots; completion of 50 shots indicated successful completion. As the participant became more successful in performing the skills and staying on-task, the tokens represented only the shots that went over the net and within the court boundary. In addition, the total number of shots represented by each token increased over clinics (i.e., 10 shots to 15 shots). After completing each task, Participant 1 viewed his data (number and velocity of shots) on the iPad, checked off the task on the schedule, and took a short break before transitioning to the next task. His parents were asked to view the video models with Participant 1 between clinics to reinforce skills.

It is important to note that the availability of an ABA or BCBA therapist is not required for the standard program and participants requiring more substantial support currently participate in the standard ACEing Autism program. In the present program, the ABA therapists provided oversight for the consistent and standardized implementation of behavioral supports to increase the degree of on-task behaviors, motivation/enjoyment, and skill improvements for those requiring more substantial support.

Figure 14. Participant 1 practicing volleys with his volunteers

Example of Implementation – Requiring Minimal Support

Participant 2 was a 12-year-old male with ASD. He had good expressive and receptive communication (e.g., was able to engage in conversation) and advanced cognitive abilities, but had difficulty initiating social interactions with peers, exhibited frustration when unsuccessful, and had trouble switching between activities. For this participant, his parents reviewed the social story and video models before the first clinic. At the beginning of each practice, the visual schedule, checklist schedule, and picture models with cues were reviewed to reduce his anxiety and help him transition between tasks. After the first few sessions, the visual schedule was no longer needed. The picture models and cues were useful in helping Participant 2 focus on the next component (cue) to be practiced (e.g., "follow-through to the opposite shoulder") and promote skill acquisition. The video models were not needed during the session, as this participant was able to perform the skills correctly after an in-person demonstration by his volunteer or coach. Congruent positive feedback was provided to reinforce the cues (i.e., "Your

follow-through went to the opposite shoulder! Great job!"). At the end of the program, Participant 2 could articulate all cues for each of the tennis skills in order. The use of tokens during the session and iPad-based feedback (number and velocity of shots) upon completion of each task were important motivating factors for Participant 2. But, the token system was faded out for later clinics, as the number of shots executed became difficult to track. Participant 2 became competitive with other participants regarding the total shots completed during practice and would state goals of increasing the number of shots to "beat his last score". Interestingly, Participant 2 did not become frustrated when the other participants were more successful than him during the tasks. He was very encouraging and supportive of the other participant's success and would give them "racquet high fives". Moreover, to encourage cooperation rather than competitiveness between participants on this court, the participants played as a team against the coaches and volunteers.

Figure 15. Participant 2 practicing forehand groundstrokes

Summary

The materials provided by ACEing Autism (i.e., standard curriculum, visual schedule, equipment, and training materials) can be implemented as an after-school program, during adapted physical education or general physical education classes during the school day (i.e., school-based delivery model), as well as a weekly program at a tennis facility (i.e., traditional delivery model). The additional behavioral supports described here (1. Social story; 2. Checklist schedule; 3. Picture and Video modeling; 4. Token system; and, 5. Technology-enhanced feedback) facilitated motor skill development, on-task behaviors, and enjoyment in individuals with ASD across the full spectrum of abilities, thus maximizing the impact of participation in ACEing Autism. A combination of multiple behavioral supports was implemented at the same time for all participants. As participants improved, fewer supports were required. For successful implementation, program staff (i.e., local program director, coaches), volunteers, and parents may need additional training to understand the importance of these supports, how to identify which supports may be useful for each participant, how to implement each support, and when it is appropriate to add or remove supports. It is important to note that every child with or without a disability learns in different ways. An important goal for teachers and coaches is to appropriately assess the child's needs and skill levels before implementing any behavioral intervention. Continued evaluations throughout the intervention are useful to identify successful strategies and individual progress.

Figure 16. A participant shows off his completion certificate and medal with Dr. Pangelinan (left) and Loriane Favoretto (right)

Chapter 4. Improvements in tennis skills and physical activity levels in children with autism spectrum disorder following a 4-week adapted tennis program

Introduction

Beyond core deficits in communication and social interaction, individuals with Autism Spectrum Disorder (ASD) also exhibit deficit in motor skills (Fournier, Hass, Naik, Lodha, & Cauraugh, 2010; Kindregan, Gallagher, & Gormley, 2015; Mosconi & Sweeney, 2015; Pan, Tsai, & Chu, 2009) and lower physical activity levels compared to typically developing peers (Bandini et al., 2013; MacDonald, Esposito, & Ulrich, 2011; Pan, 2008). The National Autism Center (2015) recommends physical activity as an emerging treatment to improve motor and social skills for children with ASD (National Autism Center, 2015). However, motor skill impairments and greater need for behavioral supports may contribute to difficulties participating in traditional recreation and sports programs (Fournier, Hass, Naik, Lodha, & Cauraugh, 2010). Therefore, adapted opportunities for children with ASD via in-school physical education (Block & Obrusnikova, 2007; Bremer and Lloyd, 2016; Grenier, 2014; Lieberman & Houston-Wilson, 2018), summer programs (Guest, Balough, Dogra, Lloyd, 2017; Johnson et al., 2018), and after-school programs (Block, 2016; Pan, 2008) are critical for these children to increase physical activity levels, motor skill development, and social skills.

Many barriers exist that preclude children with ASD from participating in physical activity and therefore perpetuate low physical activity levels and poor motor skill development. In addition to child-related factors such as deficits in motor skills and behavioral challenges, social and community factors also contribute to parents' perception of barriers for their child's participation in after-school and summer programs (Must, Phillips, Curtin & Bandini, 2015). For example, parents of children with ASD report that adults lack the skills needed to include their

child in programs, few opportunities are available in the community, and the available opportunities are costly (Must, Phillips, Curtin & Bandini, 2015). To address this gap in programming specifically tailored to meet the unique needs of individuals with ASD, organizations such as Autism Speaks have created grants that aim to increase the availability and resources for local community recreation and sports.

In addition to local programs, national non-profit organizations may also increase opportunities for children with ASD to participate in adapted physical activities and enhance motor skill development. ACEing Autism (www.aceingautism.org) is one such national non-profit organization whose mission specifically addresses barriers for participation in sport and physical activity. ACEing Autism is an adapted tennis program with 75 local programs across the US that currently serve over 1,300 individuals with ASD. The national program provides an adapted tennis curriculum, visual supports, training materials for coaches and volunteers, and equipment that can be easily implemented by local program directors including physical educators, tennis professionals, clinicians (e.g., physical, occupational, speech language, and behavioral therapists), parents, and high school/college students. The provisions for equipment significantly reduce the cost for participating (~$8-10 per small group lesson). In addition, previously published details regarding additional behavioral supports may be implemented with the ACEing Autism program to enable participants across the full spectrum to access the curriculum, improve on-task behaviors, and enhance enjoyment of the program (Favoretto et al., in press).

The social, physical activity, and motor skill outcomes from ACEing Autism programs have been measured via parent reports and disseminated to the ACEing Autism program directors; parents report improvements across all domains. However, quantitative measurement

of physical activity levels and motor skill outcomes are currently lacking. Therefore, the purpose of the present study was to quantitatively assess physical activity levels prior to, during, and after a 4-week ACEing Autism program (2 sessions per week for 1 hour per session) as well as changes in tennis skills before and after the program. Consistent with parent reports, we hypothesized that all participants would increase levels of moderate-to-vigorous physical activity during the ACEing Autism program and that participants would significantly improve in their tennis skills.

Methods

Participants

A total of 22 children and adolescents (15 males, 7 females) ages 7-19 years (M =12.7, SD = 3.37) with ASD participated in the study (see Table 3 for details). Two participants (TEN001 and TEN020) only completed the pre-test assessment but did not complete any lessons; these two participants were not included in any analyses. Prior to data collection, the Institutional Review Board at Auburn University (17-179 MR 1705) approved all procedures, and parental consent and child assent were obtained. Parents/guardians completed the World Health Organization Disability Assessment Schedule (WHO-DAS 2.0), a 12-item instrument to determine the participants' level of functioning. Each item is scored from 0 (no difficulty) to 4 (extreme difficulty, cannot do); scores were converted to a summary score that ranges from 0 (no disability) – 100 (full disability). The WHO-DAS summary scores for the participants in the program ranged from 14 to 90 (M = 39.86, SD = 18.69). Aberrant Behavioral Checklist (ABC; Aman, Singh, Stewart, & Field, 1985) rating scale was also completed by parents/guardians before the program to measure specific problem behaviors (irritability, social withdrawal, stereotypic behavior, hyperactivity, and inappropriate speech). Each of 58 items were rated on a

4-point scale, where 0 is “not at all a problem” and 3 is “the problem is severe”. Total scores for each category of behavior were computed. The ABC total scores for the participants in the program ranged from 5 to 112 (*M* = 33.10, *SD* = 23.55). Two professionals completed the 15 item Childhood Autism Rating Scale 2nd edition (CARS-2) rating scale to identify participants’ level of functioning. The raw scores were converted to summary scores to categorize the participants as follows: <27 (Minimal-to-No Symptoms of ASD), 28-34.5 (Mild-to-Moderate Symptoms of ASD), >35 (Severe Symptoms of ASD). The CARS-2 summary scores for the participants in the program ranged from 15.5 to 52.50 (*M* = 30.19, *SD* = 9.79).

Table 3. Participant Characteristics. ADHD, Attention Deficit Hyperactivity Disorder; CP, Cerebral Palsy; DY, Dyslexia; DD, Developmental Delay; NS, Noonan Syndrome; CARS2-ST, WHO-DAS, World Health Organization Disability Assessment Schedule; ABC, Aberrant Behavioral Checklist; CARS-2 ST, Childhood Autism Rating Scale Second Edition.

SubID	Age	Sex	Co-occurring Conditions	WHO-DAS Total	ABC Total	CARS-2 ST Percentile	CARS Rating
TEN002	16.99	Male		46	39	32	Mild-to-Moderate Symptoms
TEN003	11.66	Male	CP/ADHD/DD	64	---	24.25	Minimal-to-No Symptoms
TEN004	10.40	Male		26	53	24.25	Minimal-to-No Symptoms
TEN005	17.23	Male	ADHD	32	42	45.25	Severe Symptoms
TEN006	16.75	Male		26	49	35	Severe Symptoms
TEN007	9.78	Male		48	55	29.75	Mild-to-Moderate Symptoms
TEN008	11.00	Female	NS	49	24	25.25	Minimal-to-No Symptoms
TEN009	17.02	Female		35	17	35.5	Severe Symptoms
TEN010	14.36	Male		44	25	52.5	Severe Symptoms
TEN011	16.64	Male		44	33	25	Minimal-to-No Symptoms
TEN012	11.81	Male		28	14	26.75	Minimal-to-No Symptoms
TEN013	10.43	Male		21	24	20	Minimal-to-No Symptoms
TEN014	9.05	Female		14	9	22.25	Minimal-to-No Symptoms
TEN015	7.25	Female	DY	31	29	15.5	Minimal-to-No Symptoms
TEN016	16.36	Female		49	12	33	Mild-to-Moderate Symptoms
TEN017	10.92	Male		36	31	30.5	Mild-to-Moderate Symptoms
TEN018	14.63	Female				29	Mild-to-Moderate Symptoms
TEN019	11.13	Male		69	43	24.5	Minimal-to-No Symptoms
TEN021	11.63	Male		48	17	24.5	Minimal-to-No Symptoms
TEN022	8.28	Male		90	112	42.25	Severe Symptoms
TEN023	19.1	Male		22	29	49	Severe Symptoms
TEN024	9.96	Female		15	5	18.25	Minimal-to-No Symptoms

ACEing Autism Program Overview

ACEing Autism is a national non-profit organization that currently has 75 programs across the U.S. The primary mission of ACEing Autism is to connect children with ASD through tennis to positively improve the lives of children and their families. Local program directors (parents, tennis coaches, physical educators, clinicians, and high school or college students) are responsible for recruitment (participants, staff, volunteers), managing volunteers, and training. ACEing Autism has two standard program models: traditional (1 session a week for 6 weeks) and school-based (typically during physical education class or after-school program). The national program provides a curriculum using a progression from the easiest to most difficult skills, training materials for coaches and volunteers (online), visual supports (i.e., visual schedule and social story), and tennis equipment (i.e., mini nets, racquets, tennis balls, hoppers, poly spot, tennis tee). A typical session consists of a group warm-up, hand-eye coordination, racquet skills, volleys, groundstrokes (forehands/backhands), games, and a group cheer. Importantly, the curriculum allows for program directors and/or volunteers to modify the lesson to best match each child's abilities. Additional modifications, behavior supports, training methods were developed (Favoretto, Hutchison, Mowling, & Pangelinan,in press) to enable participants across the full spectrum to access the curriculum, increase on-task behaviors, and enhance enjoyment of the program.

ACEing Autism Additional Supports

The current program was administered by an adapted physical educator and tennis professional. Prior to the program, additional tennis coaches, research staff, and volunteers were trained to provide support for all participants including: how to approach participants, interact with parents, provide directed feedback, encourage participants, provide cues to teach tennis

skills, and create goals to improve for next session. Each trained volunteer was partnered with a participant (1:1 ratio or more if needed) for the duration of the program. In addition, two Board Certified Behavior Analyst (BCBA) therapists assisted with the program and provided additional behavioral management strategies as needed.

The program was held twice a week for four weeks during the summer (1 hour per session). Make-up sessions were provided for any participants who missed sessions to ensure that all participants completed a total of 8 sessions. The program used four fenced tennis courts and a tennis coach coordinated the volunteers and helped with activities to ensure participants were performing the skills correctly at each individual court. A visual schedule was placed on the side fence of the tennis court for each participant; (available at https://figshare.com/articles/Tennis_Checklist_Schedule_jpg/8859632). At the beginning of each session, the participants and their volunteer checked the schedule for the lesson (warm-up, volley, forehand, backhand, serve, and group game). They also checked off each task upon completion. Additional visual supports were provided on-court to show the participants the components of each skill (available at: https://figshare.com/articles/Breakdown_of_Tennis_Skills_-_Visual_Supports/8859602). In addition to visual supports, participants also had access to a social story, token system, and iPad feedback (for more details regarding these supports see Favoretto et al., in press). The sessions consisted of a warm-up, 4-6 tasks/games to practice each skill, and ended with a group game.

Data Collection

Pre- and post-test tennis skill assessments were conducted during the two-weeks before and after the four-week program to determine each participant's skill level. These process-oriented assessments evaluated each skill based on 5 criteria (starting body/foot position, trunk

rotation, starting racquet position, backswing, and follow-through). Each criterion was scored as either present (1) or absent (0). The scores were summed and averaged across 10 trials to create a total score for each skill. Physical activity levels were acquired using ActiGraph GT3X+ triaxial accelerometers (ActiGraph Corporation, Pensacola, FL, USA) attached to an elastic belt on their non-dominant wrist. ActiLife software (version 6.13) was used to segment ActiGraph data into 15-second epochs for participants under 18 years of age and 60-second epochs for participants over 18 years or older. Data were then categorized as sedentary, light, moderate, vigorous, and very vigorous physical activity based on the cut-points defined by Freedson et al. (2005) for participants under 18 years or Freedson et al. (1998) for participants 18 years and older. The average moderate-to-vigorous physical activity (MVPA) was computed as the sum of moderate, vigorous, and very vigorous physical activity and averaged for each of the 3 time periods: before (1 week before the program), during (all sessions averaged), and after (1 week after the program). The period of time examined was the tennis session time (e.g., 4;00-5:00pm or 5:15-6:15pm) and the equivalent time periods for the week before and after the program.

Statistical Analysis

All statistical analyses were conducted using MATLAB (Version 2018a, MathWorks™). Paired *t*-tests were used to assess the difference from pre- to post-test in the process scores for each skill (forehand, backhand, and volleys). Repeated measures analysis of variance (RM ANOVA) was used to evaluate differences in each tennis skill (pre-test to post-test) with respect to age, sex, and ABC summary score as predictors. RM ANOVA was used to assess differences in MVPA (before, during, after), with follow-up *t*-tests to determine differences between time periods. RM ANOVA was used to assess differences in MVPA (before, during, after) with

respect to age, sex, and ABC summary score. The level of significance was set to $p<0.05$ for all analyses.

Results

Table 4 depicts means and standard deviation for each skill. Paired *t*-tests revealed significant improvements from pre-test to post-test for the forehand ($t(21)= -14.69$, $p<0.001$, $d=-4.71$), backhand ($t(21)= -16.72$, $p<0.001$, $d=5.30$), and volley process scores ($t(21)= -16.31$, $p<0.001$, $d=-4.60$). Figure 17 depicts the individuals means from pre-test and post-test for the forehand (top left), backhand (top right), and volleys (bottom left). In addition to the total scores, each of the components/criteria for each skill showed significant improvements from pre-test to post-test (forehands $p<0.001$ for all cues, backhand $p<0.001$ for all cues, volley $p<0.05$ for all cues).

Table 4. Means and Standard Deviations for Each Tennis Skill

Tennis Skill	Pre-Test		Post-Test	
	M	*SD*	*M*	*SD*
Forehand	1.22	0.73	4.18	0.47
Backhand	0.89	0.75	4.31	0.49
Volley	1.95	0.88	4.94	0.14

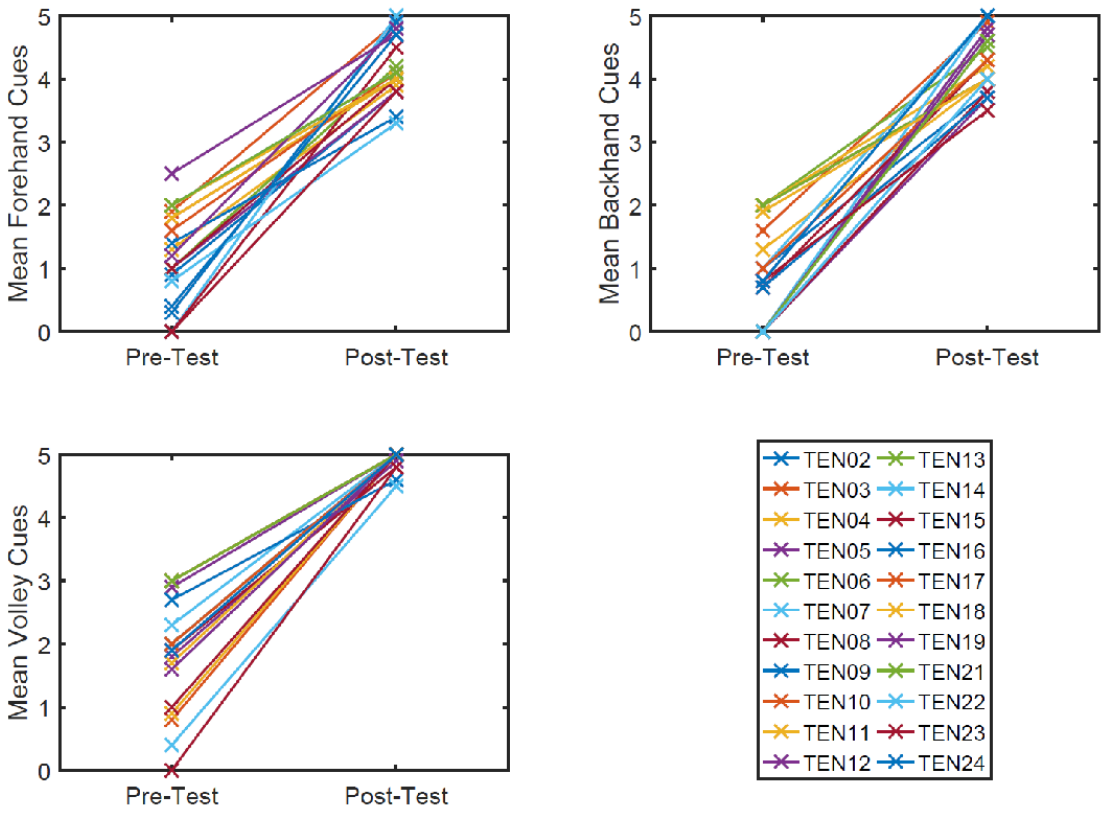

Figure 17. Pre-test and post-test process scores for each participant for the forehand (top left), backhand (top right), and volley (bottom left).

Figure 18 depicts the means and standards deviations for each skill by component (i.e., each criterion) and total scores for the forehand (top row), backhand (middle row), and volley (bottom row).

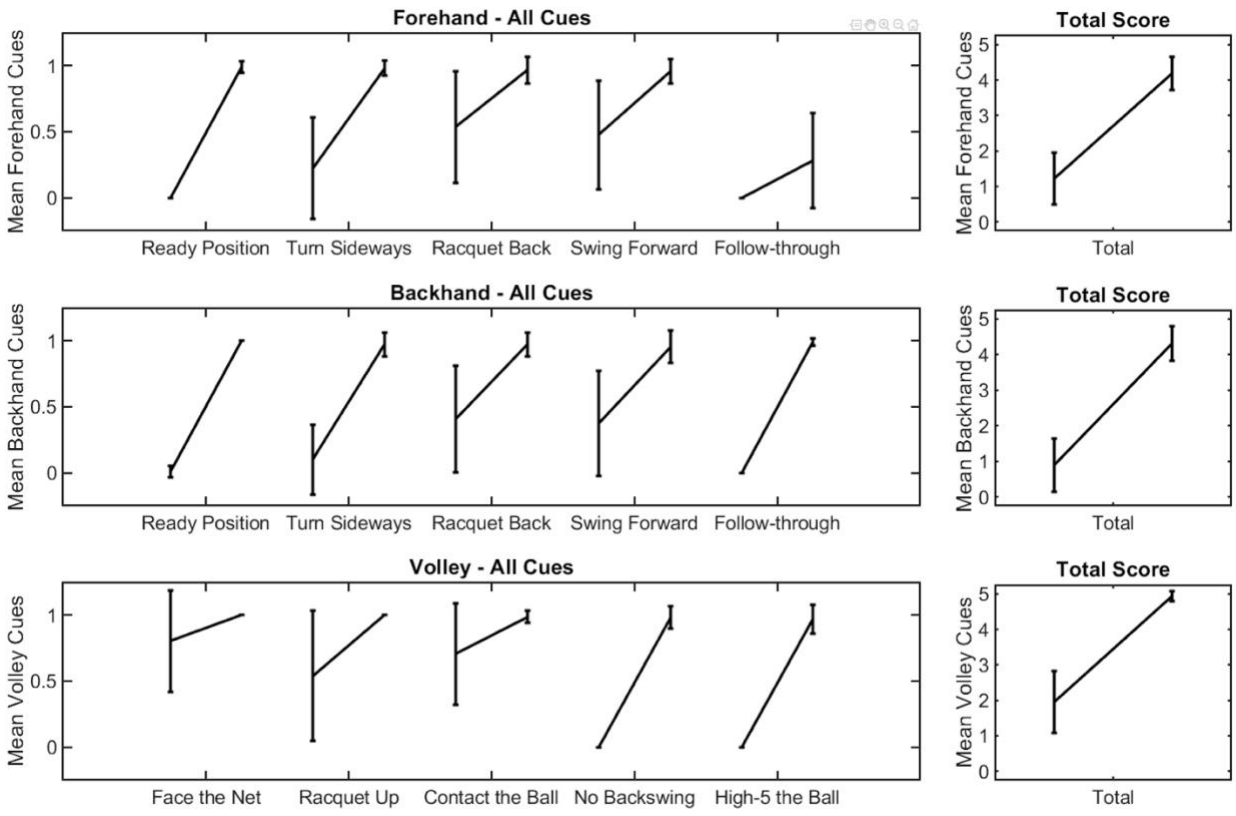

Figure 18. The means and standard deviations for each skill by component (each cues, left) and total score (right) for the forehand (top row), backhand (middle row) and volley (bottom row).

Repeated Measures ANOVA was used to examine factors that influence changes in forehand skills over time with respect to age, sex, and ABC total score. No main effects emerged for the forehand skill (p>0.05 for all), however there were significant sex x time (F(1,11)=5.37, p<0.05), sex x ABC score x time (F(1,11)=5.46, p<0.05), and age x sex x ABC score x time interactions (F(1,11)=5.22, p<0.05). Figure 19 depicts the four-way interaction between age, sex, ABC score and time. Overall, participants with greater behavioral difficulties (higher ABC scores) showed greater improvements in forehand skill, while those with behavioral difficulties (lower ABC scores) showed less improvement. However, this relationship was only statistically significant for the 8- to 12- year old male participants ($R2$ = 0.57, p = 0.05).

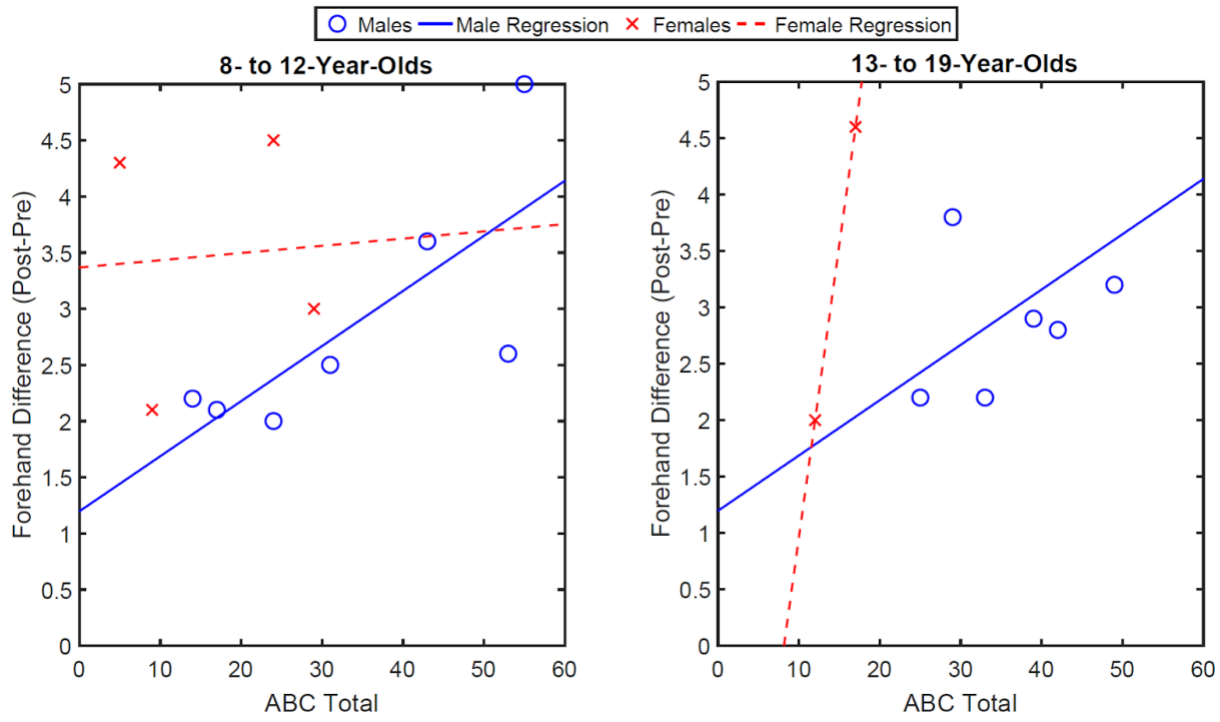

Figure 19. Forehand difference (post-test – pre-test) by ABC total scores for 8- to 12-year-olds (left) and 13- to 19-year-olds (right) by sex (males – blue circles, females – red x). The male regression lines are shown as solid blue lines and the female regression lines are shown as red dashed lines.

RM ANOVA was used to examine the factors that influence changes in backhand skills over time with respect to age, sex, and ABC total score. No main effects emerged for the backhand skills (p>0.05 for all). In addition, no interactions were observed between any of these factors (p>0.05 for all). Improvements in backhand skills were not influenced by age, sex, or behavioral problems.

RM ANOVA was used to examine the factors that influence changes in volley skills over time with respect to age, sex, and ABC total score. No main effects emerged for the volley skills (p>0.05 for all). In addition, no interactions were observed between any of these factors (p>0.05

for all). Similar to the backhand, improvements in volley skills were not influenced by age, sex, or behavioral problems.

The amount of time spent in MVPA was averaged for each tennis session (e.g., 4:00-5:00pm or 5:15-6:15pm) and equivalent time periods for the week before and after the tennis program. Figure 20 depicts the individual data (left) and group means and standard deviations (right) for MVPA before, during, and after the program. On average, out of 60 minutes, participants spent 36.24 minutes (SD: 13.64) in MVPA before the program, 52.54 minutes (SD: 4.21) during the tennis program, and 36.81 minutes (SD: 11.21) after the program. RM ANOVA was used to assess differences in MVPA (before, during, after) and revealed significant differences across these time points ($F(2,26)=15.04$, $p<0.001$). Follow-up *t*-tests revealed no difference in MVPA before or after the program ($t(13)=0.55$, $p > 0.05$, $d=.04$), but a significant increase in MVPA during the program compared to before ($t(15)=5.42$, $p < 0.001$, $d=1.57$) or after the program ($t(18)=7.06$, $p < 0.001$, $d=1.81$). RM ANOVA was also used to assess differences in MVPA with respect to age, sex, and ABC summary score. A main effect of age was observed ($F(1,4)=8.46$, $p<0.05$), such that older participants exhibited significantly less MVPA overall, compared to younger participants. However, no additional main effects or interactions were observed ($p>0.05$ for all), MVPA was not influenced by sex or behavioral problems.

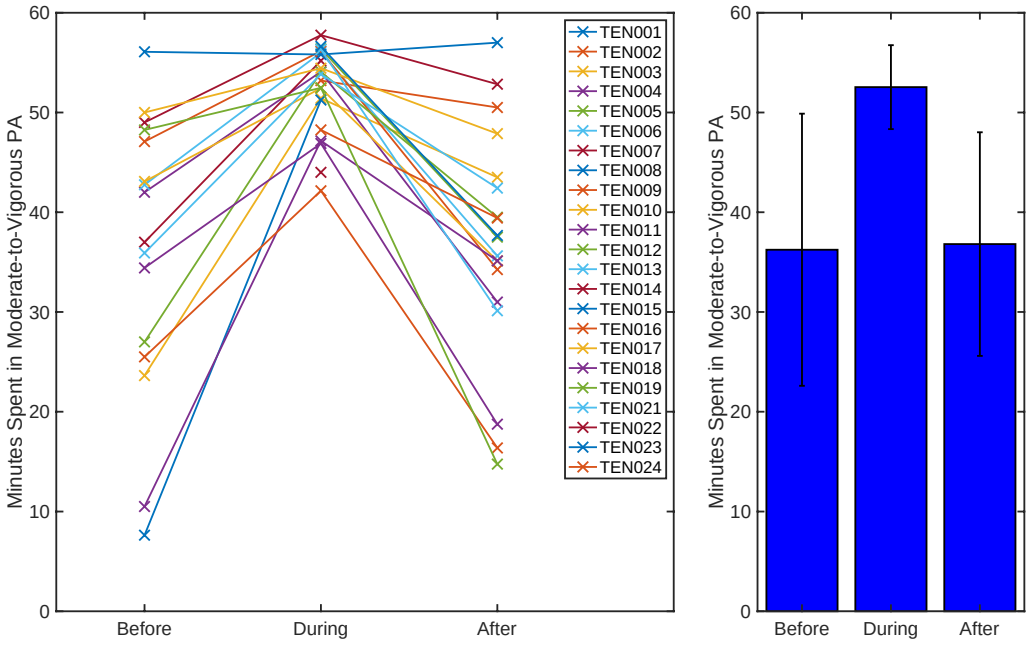

Figure 20. Minutes spent in moderate-to-vigorous physical activity by time (before, during, and after the program) for each individual (left). Group means and standard deviation for MVPA by time (right).

Discussion

This study provides new insights regarding the efficacy of a 4-week ACEing Autism program to assess physical activity and tennis skills in individuals with ASD ages 8 – 19 years. Overall, significant time main effects (pre < post) were observed for all skill components and the total scores for all skills ($p < 0.001$ for all). Significant time main effects (during > before or after the program) were also observed for time spent in MVPA ($p < 0.001$). Age, Sex, and ABC scores did not influence the degree of skill improvements for the backhand or volley and did not affect the time spent in MVPA. However, a 4-way interaction (Age x Sex x ABC x Time) was observed for the forehand skill; a significant positive relationship was observed for ABC scores

and improvements in the forehand for the young male participants. Taken together, the adapted tennis program enabled all participants to increase tennis skills and physical activity levels.

For the forehand, we observed that greater behavioral difficulties (i.e., higher ABC total scores) were associated with greater improvement for the forehand skill; this relationship was statistically significant for young male participants. These results were surprising in that we hypothesized participants with fewer behavioral difficulties would show greater improvements in tennis skills. Indeed, Baldari et al. (2009) found that the level of functioning was positively related to changes in skill performance in individuals with ASD and other disabilities participating in a 6-month Special Olympics basketball program as measured by the Special Olympics Basketball Skill Assessment. Moreover, the recent study assessed improvements in the forehand and backhand skill in novice adults ages 19-35 years old with developmental disabilities resulting from an 8-week adapted tennis program with a total of 16 sessions (Favoretto, Hutchison, Mowling, & Pangelinan, in press). Results suggested that the level of function was positively associated with the forehand and backhand skill in adults with disabilities, but not associated with *changes* in these skills.

There are several reasons for the discrepancy between previous studies and the present finding that participants with greater behavioral difficulties exhibit greater improvements in forehand skill. First, the participants with the greatest behavioral difficulties in the present study had very low pre-test forehand scores, compared to those with fewer behavioral difficulties. As such, these participants had the greatest room for improvement in the forehand skills. Second, the structure of the program was such that participants with greater behavioral difficulties received individual support from one or more trained volunteers as well as a BCBA when necessary. Third, beyond the basic visual supports provided by ACEing Autism, we also

implemented a variety of additional behavioral supports (for details please see Favoretto et al., in press) which were intended to assist participants with the greatest behavioral needs access the curriculum, remain on-task, and enjoy participating in the program. Without these supports, it is likely that the participants with the greatest behavioral difficulties would not have shown substantial improvements.

Age, sex, or behavioral problems did not influence improvements in backhand and volley skills. These results suggest that all participants were able to show similar degree of improvements over the 4-week program. Again, it is likely that the structure of the program (i.e., number of sessions per week, one-to-one volunteer support, least-to-most difficult skill progression, and dedicated practice of each skill) and additional behavioral supports (i.e., checklist schedule, visual and verbal cues for each skill, and availability of BCBAs) facilitated consistent skill improvements for all participants in only 8 sessions. In the future, it would be interesting to determine how many sessions are needed to acquire the components of each skill and whether age, sex, or behavioral problems influence the rate of skill improvement (vs. magnitude of skill improvement).

It is important to note the differences in the skill assessments utilized here and those implemented in previous research. For example, the product-based assessment created by the Special Olympics (e.g., "Special Olympics Tennis Coaching Guide," 2013) are appropriate for advanced athletes who are able to perform each of the basic sport skills. For example, for tennis, the player is rated on their skill level for the forehand, backhand, volley, serve, rally and service return. This assessment is not intended for novice players, but rather is intended as a means for determining decisioning of athletes for competition, ability matching, and determining training schedules for improving skills during practice. Another common assessment of fundamental

motor skills is the Test of Gross Motor Development, which is in its 3rd edition (Ulrich 2016, http://www.kines.umich.edu/tgmd3). This assessment evaluates product and process aspects of each motor skill and is a validated measure for children with and without disabilities. However, the only skill in the TGMD-3 that is appropriate for tennis is the single-arm strike. The present study implemented a process-oriented assessment that was developed for novice tennis players; this assessment was previously used to assess tennis skills in adults with disabilities (Favoretto et al., in press). Not only is this assessment able to capture changes in tennis skills in novice tennis players with developmental disabilities, but it also served as an excellent framework for providing appropriate verbal and visual cues to promote skill development. With that said, the present assessment did not assess product outcomes of each skill (e.g., did the ball go over the net, did the ball land in the appropriate location, was the ball hit with sufficient force or control). Therefore, additional skill assessments are needed to appropriately characterize more advanced process- and product-oriented aspects of each skill beyond the scope of the current assessment. Additional skill assessments are needed as an intermediate measure between the present assessment and that implemented by Special Olympics.

With respect to differences in physical activity levels, we found that on average, children and adolescents with ASD spent 52.54 minutes (87.57% of the tennis session) in MVPA during the tennis program. However, during equivalent times before and after the program participants only achieved around 36.24 (60.40%) and 36.80 minutes (61.33%) of MVPA, respectively. The current Physical Activity Guidelines for Americans, 2nd edition (Piercy et al., 2018) recommend that 6- to 17-year-olds should acquire at least 60 minutes MVPA daily. Participation in the tennis program was able to help participants nearly meet these recommendations on the days of the program. If full-day physical activity was assessed, it is likely that participants in the tennis

program did indeed meet the MVPA requirements on tennis days. The present results are consistent with a previous study examining the factors that influence achievement of MVPA in adapted physical education setting in adolescents with ASD (Pan, Tsai, Chu, & Hseih, 2011). MVPA was positively correlated with external regulation during inclusive physical education classes, which suggests that adolescents with ASD may require additional external support (e.g., from PE teachers, coaches, and peers) to achieve recommended levels of MVPA. Greater external regulation may be particularly beneficial for participants who perceive themselves as less physically competent (e.g., novice skill level; Ntoumanis, 2001). The adapted tennis program is highly structured, both in terms of the schedule of activities and the degree of support from coaches, volunteers, and BCBAs. Therefore, it is not surprising that participants were able to achieve a high amount of MVPA, and that this amount was very consistent across all participants (SD: 4.21 minutes). In contrast, during the equivalent times before or after the program, not only were the participants acquiring far less MVPA, they were also considerably more heterogeneous (SD: 13.64 and 11.21 minutes, respectively). These results suggest that greater external regulation via structured adapted physical activity or sport programs may be needed for children and adolescents with ASD to meet the recommended daily levels of MVPA.

There are two important take-home messages from the MVPA results. First, although the adapted tennis program did help participants make considerable progress towards meeting daily MVPA recommendations for the days of the tennis sessions, tennis sessions were only held twice a week. It is also important to note that most ACEing Autism programs implement a standard model in which lessons are offered once a week for a total of six weeks. Therefore, the program in and of itself falls short of helping participants reach the MVPA recommendations (i.e., 60 minutes of MVPA *daily)*. Second, although participants greatly improved their tennis skills, they

have not yet achieved sufficient competence to be autonomously motivated to participate in tennis or other physical activities after the program, which may help them achieve the recommended levels of daily MVPA (i.e., MVPA was similar before and after the program). Indeed, many participants in the program were unable perform more complex skills (e.g., performing serves, receiving serves, and rally), which are necessary to participate in competition or recreational practice. Given addition barriers for participants to continue practicing their tennis skills with their parents or peers after the program (e.g., court access, lack of equipment, parental motivation, transportation, etc.), it is likely that additional structured lessons are needed to achieve sufficient skill to become autonomously motivated to play tennis and achieve daily MVPA requirements via tennis alone.

Conclusion

Overall, significant improvements were observed for all tennis skills examined presently (forehand, backhand, and volley) following four weeks (8 sessions) of adapted tennis. In addition, the adapted tennis program enabled participants to make substantial progress towards achieving 60 minutes of MVPA on tennis days. This substantial improvement in skills and consistent achievement of nearly 60 minutes of MPVA was observed over a very short period of time in children and adolescents across the full spectrum. These results are very encouraging and are likely due to the structure and supports built into the program. In order for the present results to be replicated across all ACEing Autism programs, a similar structure must be maintained (e.g., well-trained volunteers, one-to-one ratio of volunteers and participants, additional behavioral supports, and availability of BCBAs). Indeed, the national ACEing Autism program has put in place staff to ensure fidelity and quality control of all local programs, so that all programs participants may exhibit similar improvements in tennis skills and achieve greater physical

activity levels. The present results suggest an increase in the number of sessions per week or longer duration of participation in adapted tennis (i.e., beyond 4 weeks) is needed for participants to continue developing the tennis skills needed to participate in recreational tennis practice and competition, as well as become autonomously motivated to be physically active through tennis.

Chapter 5. The Effects of Academic Learning Time in Physical Education (ALT-PE) During and Adapted Tennis Program for Children with Autism Spectrum Disorders

Introduction

As the prevalence of Autism Spectrum Disorder (ASD) continues to rise (Baio et al., 2018), increasing concern has turned to address behavioral challenges that are faced by individuals with ASD (Machalicek et al., 2007). Children and adolescents with ASD face communication, attention, sensory, and adaption challenges which interfere with their ability to participate in activities of daily living (Baio et al., 2018). When faced with these challenges in the classroom, behavioral problems can manifest in avoidance, elopement, and behavioral outbursts in both group and individual settings (Conroy et al., 2007). Moreover, behavioral challenges in the classroom lead to an inability to complete work, loss of instruction time, peer rejection, and school suspension. Therefore, positive behavior and learning supports are needed to minimize the impact of behavioral problems on learning.

In order to create these supports, Board Certified Behavior Analyst (BCBA), special education teachers, and researchers use behavioral coding to identify the types of behavioral problems, quantify the loss of instruction time, and determine behavioral supports appropriate for each individual (Heckaman et al., 1998). The use of direct observations to identify behavior plans (Wood et al., 2011) and to evaluate the success of those plans have been used in special education (Kern, Hilt, & Gresham, 2004). Antecedent-behavior-consequence coding is typically used during 3-18 hours of direct observation before a plan is determined (Wood et al., 2011) and after the plan is implemented to assess success (Kern, Hilt, & Gresham, 2004). Behavior plans

are developed from observations (Wood et al., 2011) and have led to the establishment of evidence-based practices for behavior supports (Wong et al., 2015).

Several of evidence-based behavioral supports are employed in general education and special education classrooms to decrease disruptive behaviors and increase on-task behaviors including visual schedules, least-to-most or most-to-least prompting, social stories, and token systems (Leach & Duffy, 2009; Wong et al., 2015). In contrast to the typical classroom setting, physical education and sport environments may be less structured, take place in large spaces with different sensory stimuli (e.g., gym or sports field), and often involve many students participating in different activities. For individuals with ASD, these factors make it difficult to access lessons, remain on-task, and participate fully with their typically developing peers. Physical education teachers have employed behavioral supports that add more structure so that students with ASD may adapt to the environment, manage sensory stimuli, stay attentive, and engage in social situations (Block, 2016; Grenier, 2014; Lavay, French, & Henderson, 2016; Lieberman & Houston-Wilson, 2018). Additional structure and organization in physical education are associated with an increase in positive behaviors for individuals with ASD (Houston-Wilson & Lieberman, 2003). Moreover, positive behaviors cultivate inclusion, increase involvement in instruction, and therefore may lead to improved motor skills (Fittipaldi-Wert & Mowling, 2009).

To evaluate student and teacher behavior in the physical education environment, the Academic Learning Time in Physical Education (ALT-PE) was developed as a standardized behavior coding system (Miller, 1985; Silverman, Dodds, Placek, Shute, & Rife, 1984). This tool categorizes behaviors based on the movement context (warm-up, skill practice, game, break, and transition) and the degree of learning involvement. Learning involvement includes movement-

specific behaviors (motor appropriate, motor supported, motor inappropriate) and other behaviors (off-task, on-task, waiting, cognitive activities). The ALT-PE coding system is widely used in research examining the general PE settings and with students that do not have disabilities.

A small number of studies have utilized the ALT-PE for students with disabilities, and even fewer have individually examined the behaviors of students with ASD in the PE setting (Block & Obrusnikova, 2007). Lisboa, Butterfield, Reif, and McIntire (1995) conducted a small study with three students with ASD (ages 11, 13, and 17 years) and used the ALT-PE to quantify the amount of time spent in motor appropriate behaviors. They found that their participants were able to achieve the desired levels of motor appropriate behaviors in a mainstreamed PE classroom (average: 33.6%), a reverse inclusion PE classroom (average: 42.6%), and an adapted PE classroom (average: 48.4%). The authors attribute the consistent levels of motor appropriate behaviors across these different classroom settings to the highly individualized, skill-based program implemented by experienced teachers and facilitated by teachers' assistants. Indeed, without tailored instruction and appropriate behavioral supports, students with disabilities typically engaged in significantly less motor appropriate behaviors during PE (Temple & Walkley, 1999). To determine the efficacy of visual supports on time-on-task, time-off-task, and time receiving assistance, Fittipaldi-Wert (2007) employed a single-subject design using the ALT-PE in four students with ASD (ages 5-9 years) during a baseline phase (regular PE) and intervention (regular PE + visual supports). This author found a significant increase in time-on-task (36.70% to 63.40%), as well as a corresponding decrease in time-off-task (29.88% to 15.23%) and receiving assistance (33.43% to 21.39%) from the baseline to intervention phase. Moreover, the participants with the most substantial improvements in time-on-task were older

and had previous classroom experience with visual supports. Taken together, these studies provide preliminary evidence that behavioral supports employed in a PE setting may enable students with ASD to engage in motor appropriate behaviors and increase on-task performance. However, additional studies are needed with a large number of individuals with ASD, with a broad age range, and varying levels of functioning to determine the factors that influence motor appropriate and on-task behaviors in a PE or adapted sport setting. Therefore, the purpose of this study was to use the ALT-PE to quantify motor behaviors (motor appropriate, motor inappropriate, and motor supported) in 19 children and adolescents (ages 7-19 years) participating in an adapted tennis program (ACEing Autism). The study determined changes in motor behaviors over time (early, middle, late) and the factors that influenced these motor behaviors. Specifically, we assessed the influence of age, sex, and level of function on time spent in motor appropriate, motor inappropriate, and motor supported behaviors. We hypothesized that overall, participants with ASD would spend a significant amount of time performing motor appropriate behaviors due to the individualized behavioral supports used in the program and highly trained coaches/volunteers implementing the program. We also hypothesized that overall, participants would show a decrease in time spent in motor inappropriate and supported behaviors over time. Lastly, we also hypothesized that younger participants and those with lower levels of functioning would spend significantly more time receiving motor support (physically help to perform a task), compared with older participants and those with higher level of functioning.

Methods

Adapted Tennis Program

ACEing Autism (www.aceingautism.org) is a national non-profit adapted tennis program with 75 local programs across the US that currently serve over 1,300 individuals with ASD. The national program provides an adapted tennis curriculum, visual supports, training materials for coaches and volunteers, and equipment that can be easily implemented by local program directors, including physical educators, tennis professionals, clinicians, parents, and high school/college students. Also, we have previously published details regarding additional behavioral supports that may be implemented with the ACEing Autism program to enable participants across the full spectrum to access the curriculum, improve on-task behaviors, and enhance the enjoyment of the program (Favoretto et al., Accepted).

The current program was administered by an adapted physical educator and tennis professional. Prior to the program, additional tennis coaches, research staff, and volunteers were trained to provide support for all participants, including how to approach participants, interact with parents, provide directed feedback, encourage participants, provide cues to teach tennis skills, and create goals to improve for next session. Each trained volunteer partnered with a participant (1:1 ratio or more if needed) for all sessions. In addition, two Board Certified Behavior Analyst (BCBA) therapists assisted with the program and provided additional behavioral management strategies as required.

The ACEing Autism program at Auburn University was held twice a week for four weeks during the summer (1 hour per session; 8 sessions total). Each participant was matched with an undergraduate student volunteer that facilitated each adapted tennis lesson. Participants were divided based on tennis skills and behavioral profiles onto four courts. On each court, one tennis coach coordinated the volunteers and managed the activities, and ensured that participants were

performing the skills correctly. Each tennis session consisted of warm-up (WU), skill practice (P), and group game (G). During skill practice, participants performed four different tennis skills (volley, forehand, backhand, and serve). The WU and G were conducted on one court with all participants together, while the P was conducted on individual courts with a maximum of four participants per court.

A visual schedule was placed on the side fence of the tennis court for each participant, available at https://figshare.com/articles/Tennis_Checklist_Schedule_jpg/8859632). At the beginning of each session, the participants and their volunteer checked the schedule for the lesson (warm-up, volley, forehand, backhand, serve, and group game). They also checked off each task upon completion. Additional visual supports were provided on-court to show the participants the components of each skill (available at: https://figshare.com/articles/Breakdown_of_Tennis_Skills_-_Visual_Supports/8859602). In addition to these visual supports, participants also had access to a social story, token system, and iPad feedback (for more details regarding these supports see Favoretto et al., Accepted). For participants with more significant behavioral challenges, the BCBAs also provided supports including timed breaks, snack reinforcers, and access to music or short videos of the participant's choice.

Participants

A total of 19 children and adolescents (13 males, 6 females) ages 7.25-19.1 years (M =13.03, SD = 3.58) with ASD participated in the study (see Table 5 for details). Note: two participants did not complete the adapted tennis program (TEN001, TEN020), two participants were absent during the video coding sessions (TEN004, TEN007), and one participant (TEN018)

was missing parent questionnaires; these participants were not included in any analyses or Table 5.

Table 5. Participant Characteristics. ADHD, Attention Deficit Hyperactivity Disorder; CP, Cerebral Palsy; DY, Dyslexia; DD, Developmental Delay; NS, Noonan Syndrome; CARS2-ST, WHO-DAS, World Health Organization Disability Assessment Schedule; ABC, Aberrant Behavioral Checklist; CARS-2 ST, Childhood Autism Rating Scale Second Edition.

SubID	Age	Sex	Co-occurring Conditions	WHO-DAS Total	ABC Total	CARS-2 ST Percentile	CARS Rating
TEN002	16.99	Male		46	39	32	Mild-to-Moderate Symptoms
TEN003	11.66	Male	CP/ADHD/DD	64	---	24.25	Minimal-to-No Symptoms
TEN005	17.23	Male	ADHD	32	42	45.25	Severe Symptoms
TEN006	16.75	Male		26	49	35	Severe Symptoms
TEN008	11.00	Female	NS	49	24	25.25	Minimal-to-No Symptoms
TEN009	17.02	Female		35	17	35.5	Severe Symptoms
TEN010	14.36	Male		44	25	52.5	Severe Symptoms
TEN011	16.64	Male		44	33	25	Minimal-to-No Symptoms
TEN012	11.81	Male		28	14	26.75	Minimal-to-No Symptoms
TEN013	10.43	Male		21	24	20	Minimal-to-No Symptoms
TEN014	9.05	Female		14	9	22.25	Minimal-to-No Symptoms
TEN015	7.25	Female	DY	31	29	15.5	Minimal-to-No Symptoms
TEN016	16.36	Female		49	12	33	Mild-to-Moderate Symptoms
TEN017	10.92	Male		36	31	30.5	Mild-to-Moderate Symptoms
TEN019	11.13	Male		69	43	24.5	Minimal-to-No Symptoms
TEN021	11.63	Male		48	17	24.5	Minimal-to-No Symptoms
TEN022	8.28	Male		90	112	42.25	Severe Symptoms
TEN023	19.1	Male		22	29	49	Severe Symptoms
TEN024	9.96	Female		15	5	18.25	Minimal-to-No Symptoms

Prior to data collection, the Institutional Review Board at Auburn University (17-179 MR 1705) approved all procedures, and parental consent and child assent were obtained. Parents/guardians completed the World Health Organization Disability Assessment Schedule (WHO-DAS 2.0), a 12-item instrument to determine the participants' level of function. Each item is scored from 0 (no difficulty) to 4 (extreme difficulty, cannot do); scores were converted to a summary score that ranges from 0 (no disability) – 100 (full disability). The WHO-DAS summary scores for the participants in the program ranged from 14 to 90 (M =40.16, SD =19.33). Aberrant Behavioral Checklist (ABC; Aman, Singh, Stewart, & Field, 1985) rating scale was also completed by parents/guardians before the program measuring specific problem behaviors (irritability, social withdrawal, stereotypic behavior, hyperactivity, and inappropriate speech). Each of 58 items were rated on a 4-point scale, where 0 is "not at all a problem" and 3 is "the problem is severe". Total scores for each category of behavior were computed. The ABC total scores for the participants in the program ranged from 5 to 112 (M = 30.78, SD = 23.72). Two researchers completed the 15 item Childhood Autism Rating Scale 2nd edition (CARS-2) rating scale to identify participants' level of functioning. The raw scores were converted to percentile scores to categorize the participants as follows: <27 (Minimal-to-No Symptoms of ASD), 28-34.5 (Mild-to-Moderate Symptoms of ASD), >35 (Severe Symptoms of ASD). The CARS-2 percentile scores for the participants in the program ranged from 15.5 to 52.50 (M = 30.59, SD = 10.46).

Data Collection

Go-Pro Hero 5 equipment was used to record three of the adapted tennis sessions (7/16, 7/25, and 8/2) and were placed on the top of the fence of each tennis court. The Academic Learning Time-Physical Education (ALT-PE) was used to evaluate behavior during the three tennis sessions. A total of 57 hours (3 sessions for 19 participants) were coded by 6 trained

undergraduate research assistants (BA, MB, MB, TE, TJ, TM) and 2 graduate research assistants (EM, LF). The coders watched the videos for 6 seconds and record observations for 6 seconds. To establish reliability between coders, all coders recorded observations for the same 20-minute video of one participant, and a comparative analysis was conducted. The coders achieved 68% agreement (57% - 84%).

The ALT-PE consists of coding the context level (C) of the lesson (e.g., transition, break, warm-up, skill practice, or game) and learning involvement (LI). The LI includes the behavior during each context (i.e., waiting, on-task, off-task, cognitive, motor appropriate, motor inappropriate, or motor supporting). Table 6 provides descriptions of the context level and learning involvement. For each participant, the total amount of time spent in each category of learning involved for each context was computed using MATLAB (Version 2018a, MathWorks™). For the present study, the analysis focused on the motor appropriate (MA), motor inappropriate (MI), and motor supported (MS) learning involvement categories for the skill practice context.

Table 6. Academic Learning Time-Physical Education (ALT-PE) categories and descriptions.

Category	Description
Context Level	
Transition (T)	After warm-up (WU) when participants were going to the court assigned and after all skill practice (P).
Break (B)	Breaks were provided to the participants after each task (WU, P, and G).
Warm-Up (WU)	Warm-up task was at the beginning of each session before skill practice.
Skill Practice (P)	During skills practice participants were performing tennis skills (Volley, forehand, backhand, and serve).
Game (G)	At the end of each session participants were on the same tennis court for a group game.
Learning Involvement	
Waiting (W)	Participants were waiting for their turn during tasks (WU, P, and G) or waiting to get back to the task during break (B).
Off-task (OF)	Participants were not engaged in the desired activity/task during warm-up (WU), break (B), skill practice (P), and game (G) (e.g., eloping, avoidance, outburst).
ON-task (ON)	Participants were engaged in the desired activity/task during warm-up (WU), break (B), skill practice (P), and game (G) (e.g., participating in the group game waiting until someone passes the ball back).
Cognitive (C)	Participants were receiving verbal instructions from volunteers, coaches, or BCBAs about the task (e.g., cues to perform the skills).
Motor Appropriate (MA)	Participants is practicing the skill appropriately (e.g., hitting volleys during volley skill practice).
Motor Inappropriate (MI)	Participants is not practicing the skill appropriately (e.g., hitting forehand during volley) or not performing the skill incorrectly (e.g., holding the racquet incorrectly).
Motor Supporting (MS)	Participants is performing the skill using support from the volunteers (e.g., hand over hand holding the racquet, or physically moving participants to perform the skill).

Transition (T), Break (B), Warm-Up (WU), Skill Practice (P), Game (G), Waiting (W), Off-task (OF), On-task, Cognitive (C), Motor Appropriate (MA), Motor Inappropriate (MI), and Motor supporting (MS).

Statistical Analysis

All statistical analyses were conducted using MATLAB. Repeated measures analysis of variance (ANOVA) was used to assess the differences for each of the motor learning involvement categories separately (i.e., MA, MI, and MS) during the skill practice context. For each motor learning involvement category, RM ANOVA was used to evaluate a within-subject factor (time), between-subjects factors (age, sex, CARS total scores, WHO-DAS summary scores, and ABC summary score), and interactions between these factors. Model selection was used to identify the most parsimonious statistical model. Follow-up *t*-tests were conducted for significant main effects and interactions. The level of significance was set to $p<0.05$ for all analyses.

Results

RM ANOVA was used to examine the factors that influenced changes in Motor Appropriate (MA) behaviors across the three sessions with respect to age, sex, CARS scores, WHO-DAS summary scores, and ABC total score. The final model included time, sex, age, and interactions between these factors; no main effects or interactions emerged for CARS total scores, WHO-DAS, or ABC total scores, so these factors were removed from the final model. Figure 21 depicts the percentage of time in MA for each of the females (left) and males (right) across time. On average, participants were spending a similar amount of time in MA across the three sessions: 54.97% (standard deviation = 16.69%) for 7/16, 55.98% (standard deviation = 13.47%) for 7/25, and 54.11% (standard deviation = 17.33%) for 8/2.

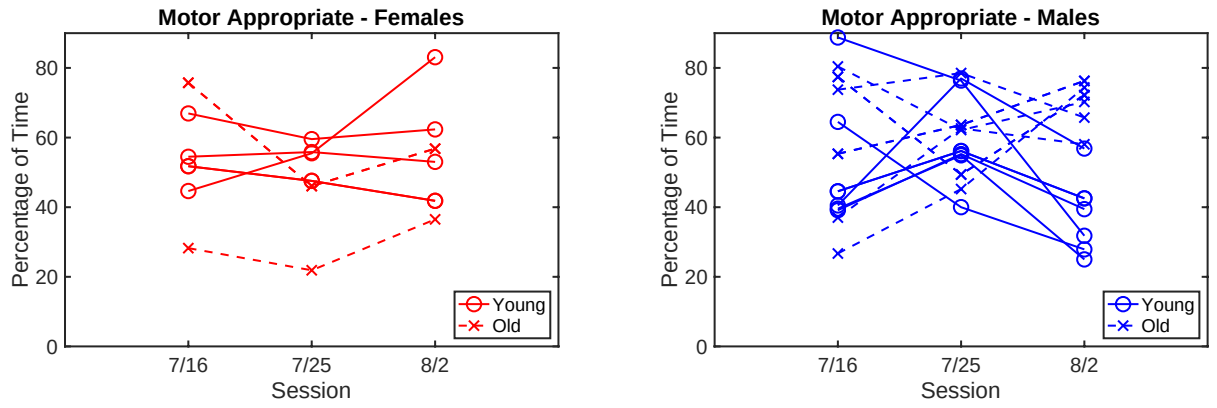

Figure 21. Left: Percentage of time in Motor Appropriate behaviors for each of the female participants for the three sessions. Young females are depicted as a circle with solid red line and older females are depicted as an "x" with dashed red line. Right: Percentage of time in Motor Appropriate behaviors for each of the male participants for the three sessions. Young males are depicted as a circle with solid blue line and older males are depicted as an "x" with dashed blue line.

There was a significant sex main effect ($F(1,14)=4.77$, $p=.047$) as well as significant sex x time ($F(2,28)=3.64$, $p=.039$) and sex x age ($F(1,14)=5.74$, $p=.031$) interactions. Follow-up analyses of the sex x time interaction (Figure 22, left), revealed that females spent slightly less time performing motor appropriate behaviors during 7/25 session (middle time point) compared to male participants ($t(10)=1.92$, $p = .07$, $d=.94$), no additional post-hoc follow-up *t*-tests for the sex x time interaction reached statistical significance. Follow-up analyses for the sex x age interaction (Figure 22, right), revealed that young male participants spent less time in motor appropriate behaviors compared to older male participants ($t(10)=2.24$, $p = .049$, $d=1.29$). No additional post-hoc follow-up *t*-tests for the sex x age interaction reached statistical significance. Note: age was continuous in the statistical model but were dichotomized into young (7- to 12-year-olds) and old (13- to 19-year-olds) for visualization purposes.

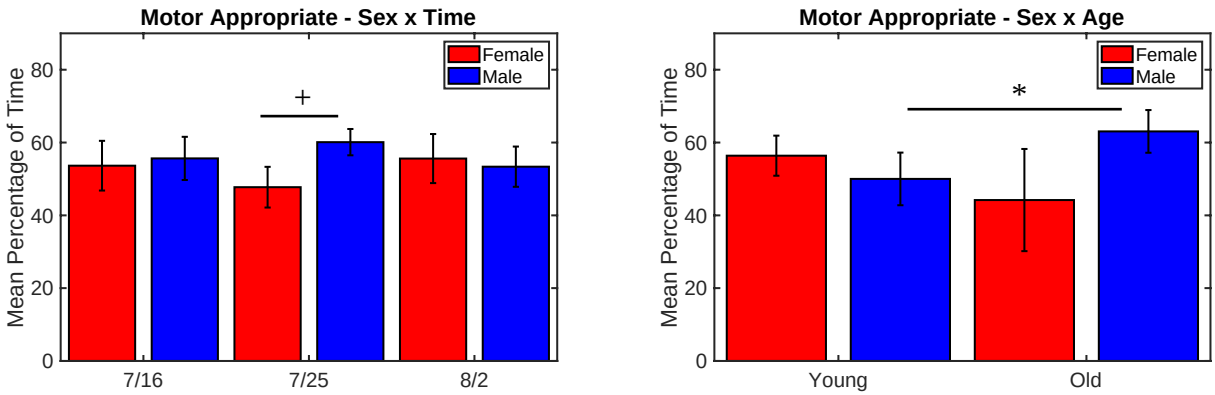

Figure 22. Left: Mean percentage of time in Motor Appropriate behaviors for females (red) and males (blue) by session. Error bars represent the standard error. + $p = 0.10$. Right: Mean percentage of time in Motor Appropriate behaviors for females (red) and males (blue) by age group (Young/Old). Error bars represent the standard error. * = $p < 0.05$.

RM ANOVA was used to examine the factors that influence changes in Motor Inappropriate behaviors across the three sessions with respect to age, sex, CARS scores, WHO-DAS summary scores, and ABC total score. The final model included time, sex, age, and interactions between these factors; no main effects or interactions emerged for CARS total scores, WHO-DAS, or ABC total scores so these factors were removed from the final model. Figure 23 depicts the percentage of time in MI for females (left) and males (right) across time for all participants. On average participants were spending less time in MI across the three sessions: 4.56% (standard deviation = 5.46%) for 7/16, 1.35% (standard deviation = 2.39%) for 7/25, and 0.39% (standard deviation = 0.86%) for 8/2.

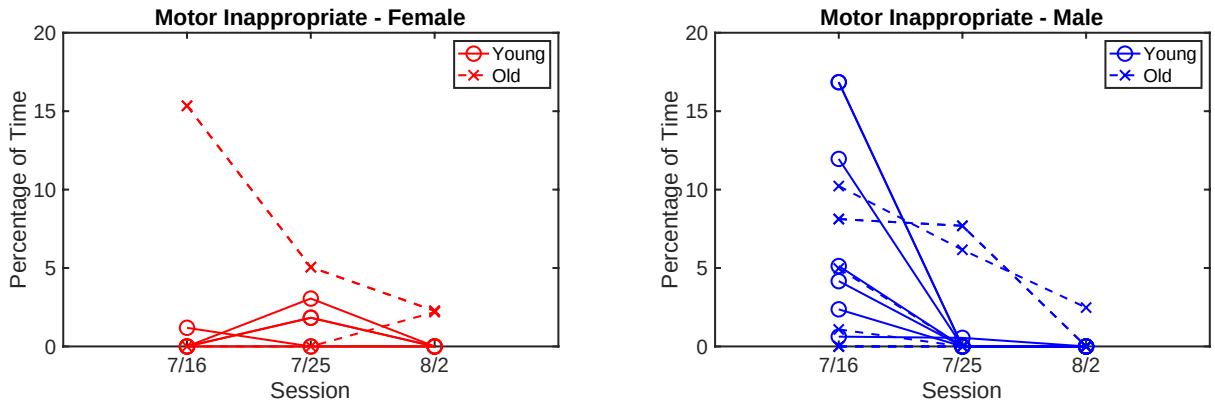

Figure 23. Left: Percentage of time in Motor Inappropriate behaviors for each of the female participants for the three sessions. Young females are depicted as a circle with solid red line and older females are depicted as an "x" with dashed red line. Right: Percentage of time in Motor Inappropriate behaviors for each of the male participants for the three sessions. Young males are depicted as a circle with solid blue line and older males are depicted as an "x" with dashed blue line.

There was a significant age main effect ($F(1,10)=6.78$, $p=.026$) and an sex x time interaction ($F(2,28)=4.20$, $p=.025$). Follow-up analyses of the sex x time interaction (Figure 24), revealed no differences across session for the females. However, there were significant differences between sessions 7/16 and 7/25 for the males ($t(11)=2.82$, $p = .02$, $d=1.00$) and between sessions 7/16 and 8/2 for the males ($t(11)=3.50$, $p = .005$, $d=1.37$). There were no significant differences between sessions 7/25 and 8/2 for the males.

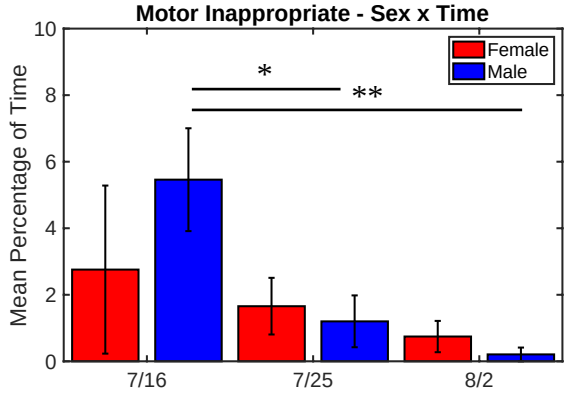

Figure 24. Left: Mean percentage of time in Motor Inappropriate behaviors for females (red) and males (blue) by session. Error bars represent the standard error. * $p < 0.05$, ** $p < 0.01$.

RM ANOVA was used to examine the factors that influence changes in Motor Supported behaviors across the three sessions with respect to age, sex, CARS scores, WHO-DAS summary scores, and ABC total score. The final model included time, sex, age, WHO-DAS, and interactions between these factors; no main effects or interactions emerged for CARS total scores or ABC total scores so these factors were removed from the final model. Figure 25 depicts the percentage of time in MS for females (left) and males (right) across time for all participants. On average participants were spending a similar amount of time amount in MS across the three sessions: 8.00% (standard deviation = 10.75%) for 7/16, 8.38% (standard deviation = 10.69%) for 7/25, and 6.99% (standard deviation = 9.99%) for 8/2.

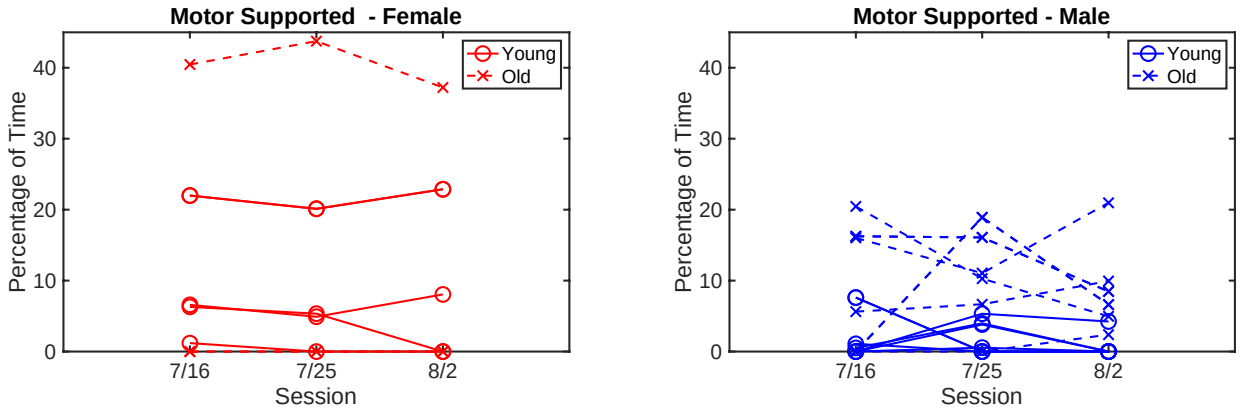

Figure 25. Left: Percentage of time in Motor Supported behaviors for each of the female participants for the three sessions. Young females are depicted as a circle with solid red line and older females are depicted as an "x" with dashed red line. Right: Percentage of time in Motor supported behaviors for each of the male participants for the three sessions. Young males are depicted as a circle with solid blue line and older males are depicted as an "x" with dashed blue line.

Significant main effects for age ($F(1,10)=9.22$, $p=.01$), sex ($F(1,10)=10.42$, $p=.01$) and WHO-DAS summary score ($F(1,10)=6.27$, $p=.03$) were found. There was a significant age x sex x WHO-DAS interaction ($F(1,10)=12.90$, $p=.01$). Follow-up analyses of the age x sex x WHO-DAS interaction (Figure 26), revealed that the older male participants are higher functioning spent more time receiving motor support than the younger male participants that were high functioning ($t(4)=-4.60$, $p = .01$, $d=-3.75$). Note: age and WHO-DAS were continuous in the statistical model but were dichotomized into young (7- to 12-year-olds), old (13- to 19-year-olds), low functioning (WHO-DAS >40) and high functioning (WHO-DAS <40) for visualization purposes. Also note that there was only 1 participant in the female young low, female old low, and female old high groups so no error bars are depicted in Figure 26.

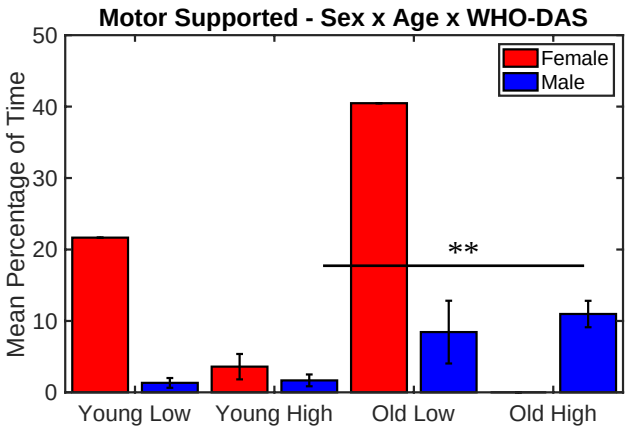

Figure 26. Percentage of time spent in Motor Supported Behaviors for females (red) and males (blue) by age (young and old) and level of function (low and high). Error bars represent the standard error. ** $p < 0.01$.

Discussion

This was the first study to use ALT-PE to measure changes in motor behaviors (MA, MI, MS) across time during skill practice in an adapted sports program in children and adolescents with ASD. On average, the participants spent over 50% of the time in MA. The older males spent

more time in MA compared with young males, but no age difference was observed for the females. With respect to time spent in MI, males exhibited a significant decrease from 7/16 to 7/25, and from 7/16 to 8/2, a similar pattern was observed for females, but this did not reach statistical significance. Lastly, the older, high functioning males spent more time in MS compared to the younger, high functioning males. Overall, these results extend the previous work examining motor behaviors in physical education for young children with ASD (Fittipaldi-Wert, 2007) and adolescents with ASD (Lisboa, Butterfield, Reif, & McIntire, 1995). This study provides additional evidence that children and adolescents with ASD may achieve consistently high levels of motor appropriate and reduce inappropriate behaviors in PE or adapted sport contexts. However, it is necessary that interventions employ highly individualized, skill-based programming implemented by well-trained staff, and employ behavioral supports.

The present results regarding the time spent in MA (or time-on-task) are consistent with Fittipaldi-Wert (2007) and Lisboa, Butterfield, Reif, and McIntire (1995). In the present study, on average, participants across the spectrum and a broad age range achieved at least 50% of the time in MA. Interestingly, these values are higher than those observed for three participants with ASD ages 11, 13, and 17 years across different PE settings (Lisboa, Butterfield, Reif, & McIntire, 1995); their participants achieved approximately 33.6% of time in MA in a mainstreamed PE classroom, 42.6% in a reverse inclusion PE classroom, and about 48.4% in an adapted PE classroom. The present results are also consistent with Fittipaldi-Wert (2007), who observed slightly higher levels of time-on-task (63.4%) for four 5- to 9-year-old participants with ASD. This discrepancy may be due to the inclusion of other LI categories such as on-task, cognitive, and waiting, in addition to MA, in the calculation of "time-on-task". In contrast, the present study focused the analysis on MA and did not include other LI categories. It is possible

that if different categories were added, these data would be more comparable. Interestingly, Fittipaldi-Wert (2007) conducted the adapted PE sessions in a one-on-one setting. In contrast, the present study was conducted in a small-group setting with up to four participants per court, and yet we were still able to achieve high values of MA.

The present study did not find that behavioral problems were associated with time spent in MA. The authors of previous studies examining children and adolescents with ASD in the PE setting also did not report that the level of function influenced MA or time-on-task. However, Fittipaldi-Wert (2007) suggested that older children with greater experience with visual supports seemed to increase in time-on-task from baseline to intervention, compared to younger children and those with less familiarity with visual supports. The present study found similar results with the older males exhibiting greater MA compared with younger males, however, this was not the case for female participants.

For MI behavior, we found sex by time interaction, such that the male participants decreased MI over time; a similar pattern was observed for the females but did not reach conventional statistical significance. This pattern may be due to the fact that the participants were more familiar with the schedule of activities or routines during the skill practice leaving less anticipation of breaks or transitions (Sanderson, Heckaman, Ernest, Johnson, & Raab, 2013). Another potential explanation for the decrease in inappropriate behaviors over time may be due to the volunteers and coaches becoming able to anticipate inappropriate behaviors and provide appropriate strategies to reduce these behaviors. Indeed, strategies such as increased vigilance by adults (e.g., coaches, volunteers) and increased proximity to students with ASD may have helped participants maintain attention or focus (Conroy, Asmus, Lagwig, Sellers, & Valcante, 2004; Sanderson, Heckaman, Ernest, Johnson, & Raab, 2013) and consequently reduce MI.

For MS behavior, the finding that older, higher functioning male participants required more support compared to younger, higher functioning males was unexpected. Instead, we predicted that lower functioning participants would require greater motor support compared to the higher functioning participants. These results may be since WHO-DAS was completed by parents who may have overestimated the level of function for the older males. Indeed, all three older males with low WHO-DAS scores (i.e., low functioning) were rated as having severe symptoms based on the CARS-2 percentile scores. Interestingly, the parent reports for the ABC for those three participants suggest that participants have more difficulties with irritability, social withdrawal, stereotypic behaviors, hyperactivity, and inappropriate speech. This degree of discrepancy between the WHO-DAS and the other behavioral assessments was not observed for the other participant groups.

Conclusions and Limitations

The primary take home message from this study was that the ALT-PE was useful in characterizing motor behaviors during the adapted tennis program, particularly for males with ASD. No study to date has examined all three categories of motor behaviors (MA, MI, and MS) during skilled practice in a large group of individuals with ASD.

The small number of female participants may have reduced the statistical power and generalizability of the findings for this population. Given that ASD affects a higher number of males compared with females, we believe the present results are representative of a broad age range and level of function. However, future studies are needed to replicate and extend the current findings with additional female participants.

The high and consistent level of MA exhibited by participants in the current study is likely due to the structure and supports built into the program (e.g., well-trained volunteers, a

one-to-one ratio of volunteers and participants, additional behavioral supports, and availability of BCBAs). Without these supports, children and adolescents with ASD may not achieve the same degree of MA, even if the same adapted tennis curriculum is implemented. Therefore, for other ACEing Autism programs or other adapted sports programs to achieve similar results, they need to adopt behavioral supports that cater to the needs of each participant.

The ALT-PE is a very tedious tool to use with such a large scale (3 sessions for 19 participants = 57 hours of coding). In order to code all of these videos, eight coders were needed. Yet, the coders achieved only 68% agreement (57% - 84%). Additional training to achieve higher levels of reliability would be very time consuming and unclear how many more hours of training would be needed to achieve 80% or higher reliability.

Although it would have been useful to examine every day of practice (all 8 sessions of the adapted tennis program), this was not possible due to equipment issues and data loss due to participant absences. For example, the Go-Pro 5 cameras were not able to withstand high temperatures for the full tennis sessions (i.e., the equipment would fail). Even if data were acquired for all sessions and for all participants, the amount of time needed to code (8 sessions x 19 participants = 152 hours of coding) would be prohibitive, and it is unclear the additional value added by these data.

For the purpose of the present study, we only examined motor behaviors (MA, MI, and MS) during skill practice. Future studies should evaluate all categories of learning involvement (i.e., on-task, off-task, cognitive skills, and waiting) across all contexts (i.e., warm-up, practice, game, breaks, and transitions). However, one difficulty of examining all contexts is that the definition of each learning involvement category may vary considerably within and across contexts (e.g., how is MA defined for warm-up vs. game). Imprecise definition of the learning

involvement categories for each context and all activities within that context may contribute to less reliable coding. Therefore, detailed definitions and coding manuals are needed specific to each context and learning involvement to reduce coding imprecision and enable comparisons across context and learning involvement.

Chapter 6. Final Conclusions

The program of research described in this dissertation was comprised of research studies. The first study examined the impact of adapted tennis on adults with developmental disabilities with respect to skill learning (Chapter 2). The second study, described in Chapters 3-5, examined the development of behavioral supports during an adapted tennis program for children with ASD (Chapter 3) and the effects of that program on physical activity levels and motor skills (Chapter 4), as well as behaviors during the program (Chapter 5).

The study described in Chapter 2 was the first to quantify differences in tennis skills and dose of practice in adults with various developmental or intellectual disabilities participating in an 8-week adapted tennis program. The overall changes in tennis skill process scores suggest that regardless of age, disability, or level of function, all participants improved the forehand and backhand during the 8-week intervention. The level of function, but not age or disability type, was associated with performance of the forehand and backhand. In comparison to other studies examining changes in adapted sport skills in adults with disabilities, the current study observed significant improvements in a fewer number of sessions. For example, the adapted soccer program examined by Chen et al. (2019) consisted of twice a week training (50 minutes per session) for 15-weeks. The adapted basketball programs examined by Guidetti et al. (2009) and Baldari et al. (2009) consisted of a 4-month (4 hour weekly) training program and a 6-month (4 hour weekly) basketball and strength and conditioning program, respectively. It is possible that changes in forehand and backhand process scores observed during this relatively short program may be due to the structure of the adapted tennis program, or perhaps the fact that tennis provides participants the opportunity to hit more shots comparing to other sports (e.g., soccer, or

basketball). Based on our significant findings and need for more behavioral supports from Chapter 2, we developed additional behavioral supports (Chapter 3).

In Chapter 3, we addressed a primary concern raised by adapted physical educators, the need for additional strategies to reduce behavioral difficulties, particularly for individuals with ASD requiring substantial support (Healy, Judge, Block, & Kwon, 2016). In addition to the materials provided by the ACEing Autism national program, visual and behavioral supports were developed as a supplement to increase motor skill learning, on-task behaviors, and enjoyment for participants across the spectrum. These behavioral supports were based on best practices for inclusive physical education (Block, 2016; Grenier, Miller, & Black, 2017; Lieberman & Houston-Wilson, 2018) and recommendations specific to children with ASD (Grenier, 2014; Healy et al., 2016; Houston-Wilson & Lieberman, 2003; Lee & Haegele, 2016; Menear & Neumeier, 2015). The behavioral supports used to supplement the standard ACEing Autism program included: 1) a social story; 2) a checklist schedule for task completion; 3) video and picture models for each skill; 4) token system; and, 5) feedback about task completion using an iPad application. The use of each behavioral support was based on the needs of each participant (i.e., communication skills, behavioral challenges, cognitive ability), but the checklist, picture models, and feedback about task completion from the iPads were consistently used for all participants for all sessions. The social story, video models, and token system were added or removed based on the participant during the course of the program but were commonly used for those with more substantial behavioral needs. Overall, we found that the implementation of these visual and behavioral support enabled participants across the full spectrum to access the adapted tennis curriculum, improve skills, and engaged in positive behaviors throughout the adapted tennis program. These supports may be implemented in both adapted PE and sport

programs for individuals with disabilities, such as ASD. These additional behavior supports were implemented during the intervention for children with ASD in Chapter 4.

In Chapter 4, significant improvements were observed for children and adolescents with ASD for all tennis skills (forehand, backhand, and volley) following four weeks (8 sessions) of adapted tennis. For the forehand, we observed that greater behavioral difficulties (i.e., higher ABC total scores) were associated with greater improvement for the forehand skill, particularly for young males. These results were surprising in that we hypothesized that participants with fewer behavioral difficulties would show greater improvements in tennis skills. Indeed, Baldari et al. (2009) found that the level of functioning was positively related to changes in skill performance in individuals with ASD and other disabilities participating in a 6-month Special Olympics basketball program as measured by the Special Olympics Basketball Skill Assessment. It is possible that the degree of improvement for young males with behavioral difficulties may be due to the visual and behavioral supports implemented during the adapted tennis program as well as greater room for improvement (i.e., low pre-test scores) exhibited by this group. In addition, the adapted tennis program enabled children and adolescents with ASD to make substantial progress towards achieving 60 minutes of MVPA on tennis days. However, the program in and of itself falls short of helping participants reach the MVPA recommendations (i.e., 60 minutes of MVPA *daily)*.

Although participants greatly improved their tennis skills, they have not yet achieved sufficient competence to be autonomously motivated to participate in tennis or other physical activities after the program, which may help them achieve the recommended levels of daily MVPA (i.e., MVPA was similar before and after the program). Indeed, many participants in the program were unable perform more complex skills (e.g., performing serves, receiving serves,

and rally), which are necessary to participate in competition or recreational practice. Given addition barriers for participants to continue practicing their tennis skills with their parents or peers after the program (e.g., court access, lack of equipment, parental motivation, transportation, etc.), it is likely that additional structured lessons are needed to achieve sufficient skill to become autonomously motivated to play tennis and achieve daily MVPA requirements via tennis alone.

Lastly, Chapter 5 we used the ALT-PE to measure changes in motor behaviors (MA, MI, MS) across time during skill practice during the ACEing Autism program in children and adolescents with ASD. On average, the participants spent over 50% of the time in MA. The older males spent more time in MA compared with young males. With respect to time spent in MI, males exhibited a significant decrease from 7/16 to 7/25, and from 7/16 to 8/2. Finally, the older, high functioning males spent more time in MS compared to the younger, high functioning males. Overall, these results extend the previous work examining motor behaviors in physical education for young children with ASD (Fittipaldi-Wert, 2007) and adolescents with ASD (Lisboa, Butterfield, Reif, & McIntire, 1995). This study provides additional evidence that children and adolescents with ASD may achieve consistently high levels of motor appropriate and reduce inappropriate behaviors in PE or adapted sport contexts. However, it is necessary that interventions employ highly individualized, skill-based programming with behavior supports implemented by well-trained staff.

Future Directions

Overall, the adapted tennis program for adults and children was effective in improving tennis skills in a short period of time across a broad age range, disability type, and level of

function. The degree of improvement in tennis skills and dose of practice for older adults with disabilities resulting from this program may be different than those reported by the literature and differ in the magnitude of observed skill improvements from the children and adolescents with ASD examined in Chapter 4. For example, older adults may require additional training session due to cognitive (e.g., memory impairments, reduced speed of processing, etc.) and physical limitations (e.g., arthritis, balance problems, visual impairments, etc.) to reap the same degree of benefit as younger participants. Future studies are necessary to quantify changes in tennis skills in a larger age range of adults with disabilities and measured over an extended training period.

In addition to examining changes in tennis skills (forehand, backhand, and volley skills), process assessments for the serve, and rally (i.e., back and forth play) would be useful to assess the range of fundamental tennis skills. With that being said, the serve and rally are challenging skills and 8-weeks (once a week) or 4-weeks (twice a week) of practice may not be sufficient for significant improvements in those skills. Thus, longer studies may be needed to observe changes in the more difficult tennis skills or studies are needed with participants with intermediate levels of skills (e.g., those participating in Special Olympics). Moreover, a longer period of time (e.g., over 6 months or a year of practice) may be needed to observe differences in age, disability, and level of function on long-term skill development and skill retention (i.e., following a period of no practice or additional lessons).

The measure of dose of practice in the adult study (i.e., tennis racquet sensors) was somewhat limited due to the decreased sensitivity of the tennis sensors to accurately measure skill performance outcomes in novice or intermediate tennis players. In order to properly characterize the quality and dose of practice, video recording of each session would be necessary.

Additional studies are necessary to examine the effects of each of the different behavioral supports implemented in the present studies (i.e., video models, visual schedule, peer support, etc.), and how these supports differ by level of function or disability category of the individual. The present studies employed a combination of these supports for each participant, and as such, we are not able to determine the unique contribution of each type of visual or behavioral support.

Although we observed that the adapted tennis program enabled participants to nearly reach the recommended levels of physical activity on tennis days, the program falls short in terms of helping participants achieve daily physical activity. As such, it is unclear if the adapted tennis program in its current format would have long-term health benefits (i.e., sustained levels of moderate-to-vigorous physical activity, reduced body fat/BMI). Therefore, additional studies are needed over a longer period of time and/or with increased number of sessions per week to determine if changes in physical activity and health are achieved.

The ALT-PE was used to measure changes in motor behaviors during skill practice. However, future studies should evaluate all categories of learning involvement (i.e., on-task, off-task, cognitive skills, and waiting) across all contexts (i.e., warm-up, practice, game, breaks, and transitions). Indeed, previous studies have found greater off-task and maladaptive behaviors during transition and breaks in children and adolescents with ASD. Therefore, particular attention to those times may be needed to develop supports to reduce behavioral difficulties across the entire tennis lesson (i.e., not just during skill practice).

Implications for Adapted Sports Programs and Practitioners

Clearly, additional research is needed to understand the impact of adapted sport programs on individuals with different disabilities across the lifespan. With that said, overall, we believe that the adapted tennis program is appropriate and scalable for different populations of

individuals with disabilities. The results of this program of research may help to provide guidance for physical educators, coaches, parents, and program directors to meet the needs of individuals with ASD and other disabilities. The evidence-based practices employed here may be used to optimize the outcomes of adapted sport programs on motor skills, physical activity levels, and adaptive behavior. The implementation of the present program required considerable training of volunteers, staff, and coaches to meet the individual needs of each participant. It is clear that highly-qualified staff directly impact the quality of learning outcomes and appropriate behaviors. In addition to preparing program staff, practitioners need to carefully evaluate their participants to determine their skill levels, behavioral characteristics, and individual needs before beginning an adapted tennis program, or any adapted sport program/intervention. These assessments enable practioners to anticipate the needs of the participants and prepare the appropriate behavioral supports. In addition, periodic evaluations are also needed to determine if behavior supports should be added/removed and the extent to which activities in the curriculum require modification.

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Appendix A - IRB

SCHOOL OF
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(NOTE: DO NOT SIGN THIS DOCUMENT UNLESS AN IRB APPROVAL STAMP WITH CURRENT DATES HAS BEEN APPLIED TO THIS DOCUMENT.)

Parent/Guardian Permission

for a Research Study entitled

"The Effects of Motivational Climates on Tennis Performance"

Your child is being asked to take part in a research study. This research study is voluntary, meaning that your child can participate in the adapted tennis program but does not have to take part in the research study. The procedures, risks, and benefits are fully described further in the parent/guardian permission form. The purpose of the study is to determine improvements in tennis skills and positive behavior during adapted tennis lessons. There will be two visits 2 weeks before and after the adapted tennis program (pre/post-assessment), each lasting about 1 hour. During these visits, your child will stand on a scale that will measure your child's weight, fat mass, and fat free mass. In addition, your child will be given a physical activity monitor that will be worn on his/her wrist. This activity monitor will measure his/her physical activity levels and quality of sleep for one week. You child will complete a walking test for 6 minutes and complete a tennis skills assessment. You will also complete a questionnaire asking about your child's activities of daily living and the program registration forms. During the adapted tennis lessons (8 sessions, 1 hour each, 8 hours total), your child's racquet will have a sensor attached to the bottom to measure different types of movements. We will video record your child to measure his/her participation, behavior, attention, ability to follow directions, and how well he/she works with others. At the end of the program you will complete a questionnaire asking about bout the impact of the adapted tennis program on your child's movement abilities, self-confidence in tennis, and social development as well as your overall perception of the adapted tennis program. Your child may experience physical fatigue (muscle fatigue and soreness) from the adapted tennis program and the physical activities in the pre/post assessment. There is also a risk of a breach of confidentiality. The study is designed to increase participants' tennis skills and physical activity. The study is designed to have substantial impact on understanding how health-related and behavioral outcomes of adapted tennis programs for individuals with and without developmental disabilities such as Autism Spectrum Disorder.

The study is being conducted by Dr. Melissa Pangelinan (Assistant Professor), Loriane Favoretto (Graduate Student) the School of Kinesiology at Auburn University. You were selected as a possible participant because:

- Your child is 19-75 years old.
- Your child is participating in an adapted tennis program with ACEing Autism at

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Yarbrough Tennis Center in Auburn, AL.

- Based on the Physical Activity Readiness Questionnaire for Everyone (PAR-Q+), your child does not have to seek further advice from a doctor or qualified exercise professional before becoming physically active.
    - If there is reason to believe that your child's health or well-being is at risk, your child must receive clearance from a physician.
- You may participate in the adapted tennis program without having to participate in the research.

What will be involved if you participate? If you decide allow your child to participate in this research study, up to two weeks prior to and following the adapted tennis program, you will be asked to come into the Pediatric Movement and Physical Activity Lab at Auburn University so that we may assess your child's body composition, tennis skills, and fitness. To measure body composition we will use a bioelectrical impedance scale. For this measurement your child will have to stand on a scale that will measure your child's weight, fat mass, and fat free mass. Your child will complete a tennis assessment to see how well he/she can perform forehand, backhands, volleys, and serves. Your child will also complete a 6-minute walk test. For this test, your child will walk back and forth between two cones (15 meters) for 6-minutes. The total distance walked will be computed and your child will be asked how hard he/she worked during the walk test. IN addition, differences in blood pressure and heart rate will be measured using a cuff placed on the upper arm. In addition, your child will be given a physical activity monitor that will be worn on his/her wrist for one week. This activity monitor will measure his/her physical activity levels and quality of sleep. The monitor will be returned at the first day of the adapted tennis program for pre-test and will be returned to the School of Kinesiology via mail for post-test (we will provide an addressed envelope with postage). You will also complete a questionnaire (WHO-DAS) asking about your child's activities of daily living and experience with tennis. You will also complete a questionnaire (program registration form) that asks about Autism symptoms, behavioral difficulties, and experience with tennis. During the first and last lesson we will record your child's movements for the forehand and backhand. Your child's racquet will have a sensor attached to the bottom. This sensor measures different types of arm movements during all of the lessons (e.g., how many, what type, and the speed of your child's movements). During the tennis program a physical activity monitor that will be worn on his/her wrist. This activity monitor will measure his/her physical activity levels and quality of sleep. The monitor will be collected after the last lesson of each week during adapted tennis program. We will also observe your child's behavior during the lessons to see how well your child's participates in activities, pays attention to directions, stays in your child's spot, and works with others. At the end of the program, you will complete a questionnaire asking about the impact of the adapted tennis program on your child's movement abilities, self-confidence in tennis, and social development as well as your overall perception of the adapted tennis program.

The total participation time, including all the assessments, will be approximately 10 hours (pre-test, 8 one-hour lessons, and post-test).

Are there any risks or discomforts? Participants may experience muscle fatigue and lack

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of motivation or boredom during the study. In the unlikely event that you sustain an injury from participation in this study, the investigators have no current plans to provide funds for any medical expenses or other costs you may incur. Breaks will be scheduled during the lesson to reduce any fatigue, boredom, or low motivation during the study. In the unlikely event of an injury, the researchers have no plans for compensation.

In addition, there is a risk of a breach of confidentiality. However, all efforts will be taken to maintain confidentiality. All information collected in this study is strictly confidential, and your child's name will not be identified at any time. The data collected will be grouped with data from other subjects for presentations at scientific conferences and publication in scientific journals. Data will be stored in a locked file cabinet in a locked room and/or on a password-protected computer. Only the investigator will have access to the data. Your child's information may be shared with representatives of Auburn University and government authorities if required by law.

Are there any benefits to yourself or others? Your child's participation is completely voluntary. Although the study is not intended to provide a direct benefit to your child, the information gathered may help us better understand factors that affect sports performance and motor skill learning. You are free to ask questions or to withdraw from participation of your child's at any time without penalty. A signed copy of this guardian permission form will be given to you.

Will you receive compensation for participating? There will be no compensation for participating.

If you change your mind about participating, you can withdraw your child at any time during the study. Your child's participation is completely voluntary. If you choose to withdraw your child, all data can be withdrawn as long as it is identifiable. Your decision about whether or not to participate or to stop your child from participating will not jeopardize your or your child's future relations with Auburn University or the School of Kinesiology.

Your privacy will be protected. All information collected in this study is strictly confidential, and your child's name will not be identified at any time. The data collected will be grouped with data from other subjects for presentations at scientific conferences and publication in scientific journals. Data will be stored in a locked file cabinet in a locked room and/or on a password-protected computer. Only the investigator will have access to the data. Your information may be shared with representatives of Auburn University and government authorities if required by law.

If you have questions about this study, *please ask them now or* contact Loriane Favoretto at lzd0035@auburn.edu or Dr. Melissa Pangelinan at melissa.pangelinan@auburn.edu or by phone at 334-844-8055. A copy of this document will be given to you to keep.

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Human Subjects Research or the Institutional Review Board by phone (334)-844-5966 or e-mail at hsubjec@auburn.edu or IRBChair@auburn.edu.

Parent/Guardian's Initials _____

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HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO PARTICIPATE.

Participant's Name	Participant's Signature	Date
Parent's Name	Parent's Signature	Date
Investigator Obtaining Consent	Investigator's Signature	Date

SCHOOL OF
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AUBURN UNIVERSITY
COLLEGE OF EDUCATION

(NOTE: DO NOT SIGN THIS DOCUMENT UNLESS AN IRB APPROVAL STAMP WITH CURRENT DATES HAS BEEN APPLIED TO THIS DOCUMENT.)

Parent/Guardian Permission

for a Research Study entitled

"The Effects of Motivational Climates on Tennis Performance"

Your child is being asked to take part in a research study. This research study is voluntary, meaning that your child can participate in the adapted tennis program but does not have to take part in the research study. The procedures, risks, and benefits are fully described further in the parent/guardian permission form. The purpose of the study is to determine improvements in tennis skills and positive behavior during adapted tennis lessons. There will be two visits 2 weeks before and after the adapted tennis program (pre/post-assessment), each lasting about 1 hour. During these visits, your child will stand on a scale that will measure your child's weight, fat mass, and fat free mass. In addition, your child will be given a physical activity monitor that will be worn on his/her wrist. This activity monitor will measure his/her physical activity levels and quality of sleep for one week. You child will complete a walking test for 6 minutes and complete a tennis skills assessment. You will also complete a questionnaire asking about your child's activities of daily living and the program registration forms. During the adapted tennis lessons (8 sessions, 1 hour each, 8 hours total), your child's racquet will have a sensor attached to the bottom to measure different types of movements. We will video record your child to measure his/her participation, behavior, attention, ability to follow directions, and how well he/she works with others. At the end of the program you will complete a questionnaire asking about bout the impact of the adapted tennis program on your child's movement abilities, self-confidence in tennis, and social development as well as your overall perception of the adapted tennis program. Your child may experience physical fatigue (muscle fatigue and soreness) from the adapted tennis program and the physical activities in the pre/post assessment. There is also a risk of a breach of confidentiality. The study is designed to increase participants' tennis skills and physical activity. The study is designed to have substantial impact on understanding how health-related and behavioral outcomes of adapted tennis programs for individuals with and without developmental disabilities such as Autism Spectrum Disorder.

The study is being conducted by Dr. Melissa Pangelinan (Assistant Professor), Loriane Favoretto (Graduate Student) the School of Kinesiology at Auburn University. You were selected as a possible participant because:

- Your child is between 8-18 years old.
- Your child is participating in an adapted tennis program with ACEing Autism at

Parent/Guardian's Initials _____

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Yarbrough Tennis Center in Auburn, AL.

- Based on the Physical Activity Readiness Questionnaire for Everyone (PAR-Q+), your child does not have to seek further advice from a doctor or qualified exercise professional before becoming physically active.
    - If there is reason to believe that your child's health or well-being is at risk, your child must receive clearance from a physician.
- You may participate in the adapted tennis program without having to participate in the research.

What will be involved if you participate? If you decide allow your child to participate in this research study, up to two weeks prior to and following the adapted tennis program, you will be asked to come into the Pediatric Movement and Physical Activity Lab at Auburn University so that we may assess your child's body composition, tennis skills, and fitness. To measure body composition we will use a bioelectrical impedance scale. For this measurement your child will have to stand on a scale that will measure your child's weight, fat mass, and fat free mass. Your child will complete a tennis assessment to see how well he/she can perform forehand, backhands, volleys, and serves. Your child will also complete a 6-minute walk test. For this test, your child will walk back and forth between two cones (15 meters) for 6-minutes. The total distance walked will be computed and your child will be asked how hard he/she worked during the walk test. IN addition, differences in blood pressure and heart rate will be measured using a cuff placed on the upper arm. In addition, your child will be given a physical activity monitor that will be worn on his/her wrist for one week. This activity monitor will measure his/her physical activity levels and quality of sleep. The monitor will be returned at the first day of the adapted tennis program for pre-test and will be returned to the School of Kinesiology via mail for post-test (we will provide an addressed envelope with postage). You will also complete a questionnaire (WHO-DAS) asking about your child's activities of daily living and experience with tennis. You will also complete a questionnaire (program registration form) that asks about Autism symptoms, behavioral difficulties, and experience with tennis. During the first and last lesson we will record your child's movements for the forehand and backhand. Your child's racquet will have a sensor attached to the bottom. This sensor measures different types of arm movements during all of the lessons (e.g., how many, what type, and the speed of your child's movements). During the tennis program a physical activity monitor that will be worn on his/her wrist. This activity monitor will measure his/her physical activity levels and quality of sleep. The monitor will be collected after the last lesson of each week during adapted tennis program. We will also observe your child's behavior during the lessons to see how well your child's participates in activities, pays attention to directions, stays in your child's spot, and works with others. At the end of the program, you will complete a questionnaire asking about the impact of the adapted tennis program on your child's movement abilities, self-confidence in tennis, and social development as well as your overall perception of the adapted tennis program.

The total participation time, including all the assessments, will be approximately 10 hours (pre-test, 8 one-hour lessons, and post-test).

Are there any risks or discomforts? Participants may experience muscle fatigue and lack

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of motivation or boredom during the study. In the unlikely event that you sustain an injury from participation in this study, the investigators have no current plans to provide funds for any medical expenses or other costs you may incur. Breaks will be scheduled during the lesson to reduce any fatigue, boredom, or low motivation during the study. In the unlikely event of an injury, the researchers have no plans for compensation.

In addition, there is a risk of a breach of confidentiality. However, all efforts will be taken to maintain confidentiality. All information collected in this study is strictly confidential, and your child's name will not be identified at any time. The data collected will be grouped with data from other subjects for presentations at scientific conferences and publication in scientific journals. Data will be stored in a locked file cabinet in a locked room and/or on a password-protected computer. Only the investigator will have access to the data. Your child's information may be shared with representatives of Auburn University and government authorities if required by law.

Are there any benefits to yourself or others? Your child's participation is completely voluntary. Although the study is not intended to provide a direct benefit to your child, the information gathered may help us better understand factors that affect sports performance and motor skill learning. You are free to ask questions or to withdraw from participation of your child's at any time without penalty. A signed copy of this guardian permission form will be given to you.

Will you receive compensation for participating? There will be no compensation for participating.

If you change your mind about participating, you can withdraw your child at any time during the study. Your child's participation is completely voluntary. If you choose to withdraw your child, all data can be withdrawn as long as it is identifiable. Your decision about whether or not to participate or to stop your child from participating will not jeopardize your or your child's future relations with Auburn University or the School of Kinesiology.

Your privacy will be protected. All information collected in this study is strictly confidential, and your child's name will not be identified at any time. The data collected will be grouped with data from other subjects for presentations at scientific conferences and publication in scientific journals. Data will be stored in a locked file cabinet in a locked room and/or on a password-protected computer. Only the investigator will have access to the data. Your information may be shared with representatives of Auburn University and government authorities if required by law.

If you have questions about this study, *please ask them now or* contact Loriane Favoretto at lzd0035@auburn.edu or Dr. Melissa Pangelinan at melissa.pangelinan@auburn.edu or by phone at 334-844-8055. A copy of this document will be given to you to keep.

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Human Subjects Research or the Institutional Review Board by phone (334)-844-5966 or e-mail at hsubjec@auburn.edu or IRBChair@auburn.edu.

Parent/Guardian's Initials _____

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HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO PARTICIPATE.

_____

Child's Name

Parent's Name	Parent's Signature	Date
Investigator Obtaining Consent	Investigator's Signature	Date

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SCHOOL OF
KINESIOLOGY

MINOR ASSENT
for ages 13-18 years
for a research study entitled

"The Effects of Motivational Climates on Tennis Performance"

You (*and your parents or guardian(s)*) are invited to be in a research study. We want to know how tennis helps children move and think.

If you want to be in the study you will come to our lab. You will stand on a special scale. It will measure how much you weigh and how much muscle and fat you have. We will see how well you can play tennis. We will also see how far you can walk in 6 minutes. We will measure how your heart works using a machine that will squeeze your arm. You will wear a special band on your wrist that measures how much you move and sleep for one week. Your parents will answer questions about what you and what you do every day. You will learn to play tennis twice a week for an hour for four weeks. Your racquet will have a sensor to measure how many shots you do. You will wear the special band to measure how much you move and sleep during the lessons. You will come back to the lab after the last week of tennis lessons and we will measure your weight, fat, and muscle. We will also measure how well you play tennis. We will also measure how far you can walk in 6 minutes and how your heart works.

Some of the time that you are playing tennis, we will have a movie camera on, taking a video of you. We can only make the video if you and your parent(s) or guardian say it's ok to do that.

When you are playing tennis your body may feel sore and may get upset. Your tennis coaches and Lori Favoretto will make sure you take breaks. You can ask for breaks at any time.

You can stop at any time. Just tell your parents or Lori Favoretto who is in charge of the program, if you do not want to play our games or be a part of the tennis program. No one will be angry with you if you stop.

If you have any questions about what you will do or what will happen, please ask your parents or guardian or ask Lori Favoretto now.

Participant's Initials _____

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If you have questions while you are playing our games or a part of the tennis program we want you to ask us.

If you decide to be in the study, please sign or print your name on the line below.

Child's Signature	Printed Name	Date
Parent/Guardian Signature	Printed Name	Date

(Parent/Guardian must also sign Parent/Guardian Permission form!)

Investigator obtaining consent	Printed Name	Date

SCHOOL OF KINESIOLOGY

AUBURN UNIVERSITY
COLLEGE OF EDUCATION

MINOR ASSENT
Verbal Script for ages 8-12 years
for a research study entitled

"The Effects of Motivational Climates on Tennis Performance"

You (*and your parents or guardian(s)*) are invited to be in a research study. We want to know how tennis helps children move and think.

If you want to be in the study you will come to our lab. You stand on a special scale. It will measure how much you weigh and how much muscle and fat you have. We will see how well you can play tennis. We will also see how far you can walk in 6 minutes. We will measure how your heart works using a machine that will squeeze your arm. You will wear a special band on your wrist that measures how much you move and sleep. Your parents will answer questions about what you and what you do every day. You will learn to play tennis twice a week for an hour. You will learn to play for four weeks. Your racquet will have a sensor to measure how many shots you do. You will wear the special band to measure how much you move and sleep during the lessons. You will come back to the lab after the tennis lessons and we will measure your weight, fat, and muscle. We will also measure how well you play tennis. We will also measure how far you can walk in 6 minutes and how your heart works.

Some of the time that you are playing tennis, we will have a movie camera on, taking a video of you. We can only make the video if you and your parent(s) or guardian say it's ok to do that.

When you are playing tennis your body may feel sore and may get upset. Your tennis coaches and Lori Favoretto will make sure you take breaks. You can ask for breaks at any time.

You can stop at any time. Just tell your parents or Lori Favoretto, who is in charge of the program, if you do not want to play our games or be a part of the tennis program. No one will be angry with you if you stop.

If you have questions while you are playing our games or a part of the tennis program we want you to ask us.

Would you like to be in our study?

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Appendix B

Forehand and Backhand Tennis Skills Assessment

Participant ID:_____ Date:_____

Instructions: Participants are going to perform 10 forehand shots, and 10 backhand shots. Each trial has 5 cues participants will be evaluated. If participant perform the cue a "YES" will be checked. If participant did not perform the cue a "NO" will be checked.

Forehand 1	Backhand 1
Ready Position YES_____ NO_____ Turn sideways YES_____ NO_____ Racquet back YES_____ NO_____ Swing forward YES_____ NO_____ Follow though YES_____ NO_____ Total YES_____ Total NO_____	Ready Position YES_____ NO_____ Turn sideways (Two hands) YES_____ NO_____ Racquet back (Two hands) YES_____ NO_____ Swing forward (Two hands) YES_____ NO_____ Follow though (Two hands) YES_____ NO_____ Total YES_____ Total NO_____
Forehand 2	**Backhand 2**
Ready Position YES_____ NO_____ Turn sideways YES_____ NO_____ Racquet back YES_____ NO_____ Swing forward YES_____ NO_____ Follow though YES_____ NO_____ Total YES_____ Total NO_____	Ready Position YES_____ NO_____ Turn sideways (Two hands) YES_____ NO_____ Racquet back (Two hands) YES_____ NO_____ Swing forward (Two hands) YES_____ NO_____ Follow though (Two hands) YES_____ NO_____ Total YES_____ Total NO_____
Forehand 3	**Backhand 3**
Ready Position YES_____ NO_____ Turn sideways YES_____ NO_____ Racquet back YES_____ NO_____ Swing forward YES_____ NO_____ Follow though YES_____ NO_____ Total YES_____ Total NO_____	Ready Position YES_____ NO_____ Turn sideways (Two hands) YES_____ NO_____ Racquet back (Two hands) YES_____ NO_____ Swing forward (Two hands) YES_____ NO_____ Follow though (Two hands) YES_____ NO_____ Total YES_____ Total NO_____
Forehand 4	**Backhand 4**
Ready Position YES_____ NO_____ Turn sideways YES_____ NO_____ Racquet back YES_____ NO_____ Swing forward YES_____ NO_____ Follow though YES_____ NO_____ Total YES_____ Total NO_____	Ready Position YES_____ NO_____ Turn sideways (Two hands) YES_____ NO_____ Racquet back (Two hands) YES_____ NO_____ Swing forward (Two hands) YES_____ NO_____ Follow though (Two hands) YES_____ NO_____ Total YES_____ Total NO_____
Forehand 5	**Backhand 5**
Ready Position YES_____ NO_____ Turn sideways YES_____ NO_____ Racquet back YES_____ NO_____ Swing forward YES_____ NO_____ Follow though YES_____ NO_____ Total YES_____ Total NO_____	Ready Position YES_____ NO_____ Turn sideways (Two hands) YES_____ NO_____ Racquet back (Two hands) YES_____ NO_____ Swing forward (Two hands) YES_____ NO_____ Follow though (Two hands) YES_____ NO_____ Total YES_____ Total NO_____

Appendix C

ALT-PE RECORD SHEET

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
S___	C																										
	LI																										

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
S___	C																										
	LI																										

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
S___	C																										
	LI																										

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
S___	C																										
	LI																										

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
S___	C																										
	LI																										

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
S___	C																										
	LI																										

CONTEXT LEVEL (C)			LEARNER INVOLVEMENT LEVEL (LI)	
General Content	Subject Matter Knowledge Content	Subject Matter Motor Content	Not Motor Engaged	Motor Engaged
-Transition (T)	-Technique (TN)	-Skill practice (P)	-Interim (I)	-Motor Appropriate (MA)
-Management (M)	-Strategy (ST)	-Scrimmage/Routine (S)	-Waiting (W)	-Motor Inappropriate (MI)
-Break (B)	-Rule (R)	-Game (G)	-Off-task (OF)	-Supporting (MS)
-Warm-up (WU)	-Social Behavior (SB)	-Fitness (F)	-On-task (ON)	
	-Background (BK)		-Cognitive (C)	