SWACSM Abstract

Evaluation of Skipping in College Students With and Without Autism Spectrum Disorder

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ABSTRACT

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that affects social interactions and behaviors. Previous research has shown that children with ASD demonstrate motor skill deficits in comparison to their neurotypically developing peers. However, it is unknown whether these motor skill deficits translate into adulthood. **PURPOSE**: The study intended to evaluate skipping performance and kinematics in college students with and without ASD to identify potential deficits. **METHODS**: A total of 20 college students, 10 with ASD and 10 without, participated in this study. Following a skipping demonstration, each participant completed three skipping trials. Data was collected using a three-dimensional (3-D), 12-camera motion capture system at 120Hz using reflective markers that were placed on participants' upper and lower extremities. Developmental scoring of skipping performance was performed using a combination of Everyone Can! and the Halverson Developmental Sequences for Skipping. Data were processed using Cortex, Visual 3D, Matlab, and SPSS software. Center of mass excursion, the peak velocity of joint extension during the stance phase, and peak joint angles of the hip, knee, and ankle of the dominant leg were extracted and compared between both groups. Independent t-tests were used to compare normally distributed kinematic variables and Mann-Whitney U test were used to examine the center of mass excursion as well as the difference in developmental scores between both groups with an alpha level of ≤ 0.5. **RESULTS**: Individuals with ASD performed less proficiently in skipping than individuals without ASD as assessed by the developmental scoring. However, there were no statistically significant differences for the peak joint angles, velocities, or vertical center of mass excursion. The ASD group demonstrated an increased medial-lateral center of mass displacement (p= 0.026). **CONCLUSION**: Participants with ASD were less proficient in their skip performance in comparison to participants without ASD. Given that skipping is a motor skill used in many common sports and leisure activities, interventions addressing the ability to skip proficiently may promote participation in these activities and help individuals with ASD lead more physically active lives.

BACKGROUND: Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that affects social interactions and behaviors (American Psychiatric Association, 2013); individuals with ASD may demonstrate a deficit in gross motor skills which include reduced balance and posture stability, walking and running gait deficits, and impaired gross and fine motor skills. Extensive research has shown that children with ASD display motor skill deficits in comparison to their neurotypically developing peers. It is predicted that motor skill deficits may contribute to lower levels of physical activity in ASD, which can then lead to a sedentary lifestyle or obesity. It is unknown whether these motor skill deficits carry over into adulthood. Few studies have focused on observing the kinematics of fundamental motor skills in adults with ASD, but not enough evidence exists to conclude how motor skill performance is affected into adulthood. Studying advanced gross motor skill performance might give us a better understanding of motor development in individuals with ASD. **PURPOSE**: The study aimed to evaluate skipping performance in college students with and without ASD. We hypothesized that young adults with ASD would demonstrate lower developmental scores and deficient skipping kinematics compared to young adults without ASD. **METHODS**: A total of 20 college students, 10 with ASD and 10 without, provided consent to participate in this study. Participants were eligible to participate in the study if they were participating in a minimum of 100 minutes of physical activity per week. Individuals in the ASD group also were required to self-disclose a formal diagnosis of ASD. Participants were excluded from this study if they (a) had experienced seizures, stroke, or traumatic brain injury, (b) had a severe visual impairment preventing independent navigation, (c) had a gross sensory defect, (d) required the use of an assistive ambulatory device, and/or (e) displayed significant physical impairments that would limit participation in fundamental motor skills. All participants were asked to provide written informed consent. This protocol was approved by the University Institutional Review Board. Following a skipping demonstration, each participant completed three skipping trials. Data was collected using a three-dimensional (3-D), 12-camera motion capture system at 120Hz using reflective markers that were placed on participants' upper and lower extremities. Developmental scoring of skipping performance was performed using a combination of Everyone Can! and the Halverson Developmental Sequences for Skipping. Two participants with ASD were identified as not performing a skipping movement and were excluded from further analysis. Kinematic data were processed using Cortex (Motion Analysis), Visual 3D (C-Motion, Inc.), MATLAB (Mathworks), and SPSS software. Marker

trajectory data were filtered using a low-pass fourth-order Butterworth filter with a cutoff frequency of 12 Hz. The kinematics of the model were measured by determining the shift from each segment's triad of reflective markers to the position and orientation of each segment assessed from the standing calibration trial. Center of mass excursion, the peak velocity of joint extension during the stance phase, and peak joint angles of the hip, knee, and ankle of the dominant leg were extracted and compared between both groups. The Shapiro-Wilk test was used to assess data distribution. Independent t-tests were used to compare normally distributed kinematic variables and Mann-Whitney U test were used to examine the center of mass excursion as well as the difference in developmental scores between both groups with an alpha level of ≤ 0.5. **RESULTS**: Individuals with ASD performed less proficiently in skipping than individuals without ASD as assessed by the developmental scoring (Table 1). The Everyone Can developmental sequence for skipping displayed a lower proficiency in skip performance, specifically in the hop and smooth integration components, as well as the composite score among individuals with ASD. The Halverson Developmental Sequences for Skipping also revealed significant differences in arm ($U = 21$, $p = 0.015$) and leg ($U = 35$, $p = 0.045$) movements during skipping performance among young adults with ASD. There were no statistically significant differences in the peak joint angles of the hip, knee, or ankle, and no statistically significant differences were found in the vertical center of mass excursion (Table 2). The ASD group demonstrated an increased medial-lateral center of mass displacement ($p = 0.026$). **DISCUSSION**: Children with ASD tend to acquire and mature in their motor skill performance later than typically developing children. Although skipping is one of the least common motor skills to be used after grade school, it is nonetheless the most complex gross motor skill that is developed in childhood. Skipping requires coordination between the legs and arms to move in opposition to one another, as well as sufficient lower extremity muscle strength. Given that skipping is a motor skill used in many common sports and leisure activities, the ability to skip proficiently may promote participation in these activities and help individuals with ASD lead more physically active lives. The purpose of this study was to evaluate skipping performance in college students with and without ASD. Participants with ASD were less proficient in their skip performance in comparison to participants without ASD, as indicated by the lower composite scores on the Everyone Can! criteria, and the lower scores on the Halverson Developmental Sequence leg action and arm action (Table 1). Additionally, specific deficits were identified in criteria b and d of the Everyone

Can! Criteria which identify key mechanical components of skipping, and in criteria e which assesses the smoothness of movement. Individuals with ASD were not as successful in performing the skipping action. However, these results overall were not reflected in the biomechanical variables chosen for analysis. Peak lower extremity joint flexion and extension, peak lower extremity joint extension velocity, and vertical center of mass excursion were similar between groups (Table 2). Many participants performed the skipping in a leisurely manner and there was a high degree of variability in the kinematic results; it is possible that greater kinematic differences may have been seen if participants had been asked to power skip with a more explosive movement pattern. Although we did not identify statistical significance, large effect sizes with greater peak ankle dorsiflexion, peak ankle plantar flexion, and peak ankle plantar flexion velocity in the individuals with ASD. Potentially, individuals with ASD exhibited decreased ankle stability, contributing to a less coordinated performance. In terms of kinematics, the only statistically significant difference identified was increased medial-lateral center of mass excursion in individuals with ASD (Table 2). A large effect size ($r = 1.06$) associated with the medial-lateral center of mass excursion supports this significance. The increased center of mass excursion indicates that individuals with ASD may have trouble coordinating and may not have sufficient strength and stability to propel themselves forward, therefore compensating by moving in a side-to-side motion. Given the evidence of difficulties in movement coordination among children and adults with ASD, this finding does not come as a surprise (Fournier et al., 2010; Isenhower et al., 2012; Travers et al., 2013). Although more analysis of various motor skills is needed, this evidence implies that issues with movement coordination may persist into adulthood. Limitations: Although some important results were found in our study, there were a few limitations. Only 8 out of 10 ASD participants were able to perform what was determined to be a skipping movement, so two participants were excluded from our kinematic analysis. This further reduced our already fairly small sample size. It is possible that more deficits in skipping could be identified with a larger sample. Another limitation may have been that skipping was performed indoors in a laboratory which may have placed individual constraints of the laboratory where the skill took place. Finally, our ASD participants were high functioning as all our ASD participants were college students. According to the literature, individuals with ASD will be largely free from symptoms of the disorder by adulthood (Lancet, 2018). This is especially true for individuals with high-functioning autism, so looking at moderate to low

functioning ASD participants may be something to consider in further studies. **CONCLUSION**: Individuals with ASD exhibited kinematic and developmental differences in skipping performance compared to individuals without ASD. Lack of instruction and participation in activities that involve skipping movements may have been a factor in the skipping performance of college students with ASD. The results of this study provide evidence that young adults with ASD perform a less developmentally mature version of a skip compared to their peers without ASD. Deficits observed in skipping may be barriers to participating in sports and physically active leisure activities. Given the severe health consequences related to sedentary behavior, it is important to attend to these barriers to lead a physically active lifestyle. Considering these results, practitioners should implement motor skill interventions for children with ASD as increased confidence in performing complex motor skills may aid in promoting healthy behaviors in this population.

Table 1. Developmental scoring of skipping.

Variable	Control	ASD	*p*	Effect Size
Everyone Can! Composite Score	15.0 (0)	10.5 (8)	0.008*	1.344
a. Facing and looking forward	3.0 (0)	3.0 (0)	1	0
b. Steps forward and then hops on the same leg, repeating cycle while alternating legs	3.0 (0)	2.0 (2)	0.018*	1.002
c. Arms move in opposition to legs, slightly flexed at waist level	3.0 (0)	3.0 (2)	0.241	0.432
d. Period of nonsupport during the hop phase before weight transfer to opposite foot	3.0 (0)	2.5 (2)	0.044*	0.78
e. Smooth integration (not mechanical or jerky)	3.0 (0)	1.0 (3)	0.014*	1.099
Halverson Leg Action	3.0 (0)	2.5 (2)	0.045*	0.524
Halverson Arm Action	3.0 (0)	2.0 (2)	0.015*	1.125

Note. Data presented as median (interquartile range).
* indicates statistical significance, $p \leq 0.05$

Table 2. Center of mass and lower extremity kinematics during skipping.

Variable	Control	ASD	*p*	Effect Size
Medial-Lateral COM Displacement (m)	0.03 (0.03)	0.08 (0.1)	0.026*	1.06
Vertical COM Displacement (m)	0.25 (0.08)	0.27 (0.04)	0.155	0.805
Peak Hip Flexion (°)	50.77 ± 9.79	54.60 ± 7.74	0.368	0.434
Peak Knee Flexion (°)	43.34 ± 8.96	44.79 ± 8.69	0.734	0.164
Peak Ankle Dorsiflexion (°)	26.39 ± 4.18	30.65 ± 7.75	0.155	0.684
Peak Hip Extension (°)	-11.04 ± 6.90	-12.87 ± 14.84	0.733	0.158
Peak Knee Extension (°)	3.69 ± 6.98	6.37 ± 8.42	0.471	0.347
Peak Ankle Plantar Flexion (°)	-19.56 ± 8.33	-25.76 ± 9.50	0.160	0.694
Peak Hip Extension Velocity (°/s)	-329.22 ± 67.39	-349.76 ± 89.30	0.585	0.26
Peak Knee Extension Velocity (°/s)	-297.78 ± 50.08	-302.75 ± 72.43	0.866	0.08
Peak Ankle Plantar Flexion Velocity (°/s)	-516.15 ± 81.00	-576.86 ± 127.92	0.237	0.567

Note. Data presented as median (interquartile range) or mean ± standard deviation.

* indicates statistical significance, $p \leq 0.05$

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