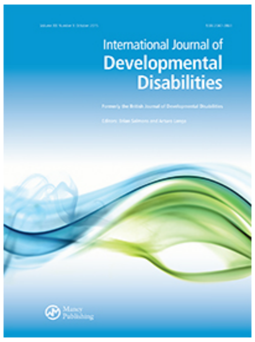

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The impact of badminton lessons on health and wellness of young adults with intellectual disabilities: a pilot study

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Background: Physical activity has been proposed as a context to foster the healthy development of individuals and reduce the risk of many chronic problems. This study evaluates the impact of badminton lessons on health and wellness in young adults with intellectual disabilities (ID).

Methods: Eighteen participants with ID (14 males and 4 females, aged 19-26) and with little or no experience in badminton were assigned to an exercise group and a control group. The curriculum selected was Shuttle Time Starter Lessons. The exercise group practiced for 50 min each session, twice a week for 10 lessons with peers, while the control group maintained a regular life schedule. Physiological measures, motor performance, Special Olympics Individual Badminton Skills Assessment; and psychological measures were conducted before and after the program. A Wilcoxon signed-rank test was conducted to compare pre- and post-tests in each group.

Results: The significantly reduced resting heart rate, longer walking distances in the 6-minute walk test, and better performance in badminton skills were evident in the exercise group. Further, a significantly increased left frontal alpha asymmetry was seen in the exercise group with participants expressing positive effects after the inclusive badminton program. Finally, resting EEG frontal asymmetry seemed to be reflective of emotion in persons with ID. **Conclusions:** Shuttle Time Badminton Lessons could be feasible for adults with ID. School teachers and coaches may adapt it to improve health and wellness and acquire badminton skills in adults with ID. In addition, the inclusive environment can motivate their participation.

Keywords: motor performance, exercise program, EEG, emotion, developmental disabilities

Physical activity has been widely proposed as a context for fostering healthy development, while decreasing the risk of many chronic problems in the general population (Haskell *et al.* 2007, Durstine *et al.* 2013, Booth *et al.* 2008). However, past research has shown a steep decline in physical activity in children and through their adolescent development into young adulthood (Corder *et al.* 2019, Telama *et al.* 2005). During the college years, there is evidence to show that young adults begin to form lifestyle behavior patterns that strongly influence their later life behavior (Nogueira *et al.* 2009). Currently, a growing number of colleges offer opportunities for young adults with intellectual disabilities (ID) to participate in physical activities (Grigal *et al.* 2011).

ID is the most prevalent worldwide developmental disability in human society (Maulik *et al.* 2011). Persons with ID are known to have significant limitations in intellectual functioning and adaptive behaviors, which originate before the age of 18 years (Schalock *et al.* 2010). In particular, a significant decline in physical and motor functions (e.g. abdominal strength/endurance, static balance, and manual dexterity) takes place in persons with ID during adulthood (Lahtinen *et al.* 2007). The information mentioned above highlights the need to find effective strategies to increase physical activity participation of young adults with ID. In a systematic review of 362 physical activity studies in people with ID between 2000 and 2014, Pitchford *et al.* (2018) found only 8% of these studies evaluated the outcomes of physical activity interventions. Moreover, most training intervention studies relied on individual

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sports, such as walking, jogging, or cycling, and were conducted in an isolated laboratory setting.

The purpose of the study presented here is primarily to create a team sport program in the gymnasium to investigate ways to mitigate adverse health outcomes in young adults with ID. Notably, one of the hallmark deficits in ID is poor physical and motor performance (e.g. low muscular strength and cardiovascular endurance) compared to their typical peers (Hartman *et al*. 2010, Salaun and Berthouze-Aranda 2012). Despite the known benefits of physical activity that are known to improve physical and motor performance in people with ID (Golubović *et al*. 2012, Giagazoglou *et al*. 2013), numerous barriers exist that prohibit them from regular physical activity participation. Students with ID are routinely excluded from organized sport opportunities and many remain more sedentary compared with students without ID (Myers *et al*. 1998, Miller *et al*. 2009, Thomas 2000). Interestingly, there is strong evidence that young adults with ID who attend colleges indicate similar goals as those of their typical peers, i.e. to be independent, have friendships with peers, and attend class and social events (Grigal *et al*. 2001).

To date, sports have provided a way to break down barriers and promote inclusion of individuals with ID (McConkey *et al*. 2019, Özer *et al*. 2012). Notably, an inclusive sport program was launched by the Special Olympics in 1950s. Over the years, this program, in which players with ID and those without ID, but with similar skill levels participate in the same sports teams for training as well competition, has yielded many benefits, including developing togetherness (McConkey *et al*. 2019), socially appropriate behaviors (Özer *et al*. 2012), and improved leisure skills and physical functioning (Baran *et al*. 2013, Castagno 2001). However, information on whether this set up endows positive effects on the psychological/emotional (e.g. affective response, depression) in the inclusive sport settings for individuals with ID is still limited. The study presented in this paper takes place within the context of inclusive sport on campus. It would be expected such campus inclusive sports programs would promote health and well-being in physical as well as psychological perspectives among young adults with ID.

The concept of resting brain frontal asymmetric activity is widely applied as a biological marker to produce an affective response to emotion-eliciting events (Harmon-Jones and Gable 2018). Resting alpha band (8–12 Hz) frontal asymmetry in electroencephalograms (EEG) has been used to reflect positive or negative affective processes from adverse memories (Meyer *et al*. 2014), films (Smith *et al*. 2017), and advertisements (Ohme *et al*. 2010). These studies noted that increased activation of the left hemisphere relative to the right occurs during positive affect and is associated with an approaching behavior and positive feelings, whereas increased activation of the right hemisphere relative to the left is associated with an avoidance and withdrawal system and negative feelings. Moreover, resting frontal alpha asymmetry (FAA) is a predictor of changes in affective response associated with exercise.

Woo and colleagues (2010) found that compared to the level of baseline, resting left FAA and self-reported vigor scores were all elevated when exercise intensity increased in college students. Additionally, the research revealed that the left FAA may, in fact, be a novel neurophysiological marker of habitual physical activity. In another study, the greater levels of moderate physical activity were associated with greater left FAA in the general population (Threadgill *et al*. 2020). As for individuals with ID, children with Down syndrome (DS) displayed a similar relationship between FAA and affective response while watching emotional video clips (Conrad *et al*. 2007). Similarly, the EEG-affect-exercise relationship was seen in adults with ID, Chen *et al*. (2016) observed an association between FAA and rated perceived exertion (RPE) level in 20-min treadmill walking among young adults with ID. Participants who expressed high right FAA reported a high RPE level. In sum, resting FAA seems to be reflective of affective response to exercise in persons with ID. This study uniquely applies the FAA to understand their emotion toward the inclusive sport program.

Badminton is the second most popular participatory sport in the world; yet, the studies about the impact of badminton participation on health markers in typical populations are scare (Chan and Lee 2020, Nassef *et al*. 2020, Patterson *et al*. 2017). The increased maximal power output and high-density lipoprotein cholesterol and decreased blood pressure and resting heart rate were reported after badminton exercise participation. Although badminton is gaining popularity in Special Olympics, to the best of our knowledge, there is only one badminton study in people with ID that examines its training effect on basic badminton skills (e.g. clear and serve) for children with ID (Karahan *et al*. 2012). In this first of its kind study, we systematically investigate the application of the badminton sport in young adults. We hypothesize that there will be marked improvements in physiological functioning, motor performance, and psychological measures in adults with ID due to their participation in a campus inclusive badminton program.

Methods

Participants

A total of 18 participants with mild to moderate ID (as seen in Table 1, 14 males and 4 females, aged 22.28 ± 1.84 years, IQ level: 67.64 ± 14.11) with little or no experience in badminton or racket sports participated in this study. All participants were from a convenience sampling. They were students enrolled in a 4-year federally approved comprehensive transition post-secondary program for adults with ID at a Southeastern university in the United States. All participants could live independently on or off-campus and chose at least one college-level course per semester to audit or for credit. Therefore, participants in the present study were considered to have the basic ability to comprehend the instruction and express their feeling during the sports program.

Prior to the study, the interested parents/guardians were contacted with the parental permission forms, and participants were provided with the informed consent forms for their signatures. The researcher used the physical activity readiness questionnaire (PAR-Q) to screen if there were any cardiovascular issues or physical or visual impairment among participants that may exacerbate their physical performance. No participants required further medical approval for exercise participation. All protocols were approved by the Human Subjects Institutional Review Board of the University.

Procedure

Each participant with ID was scheduled a laboratory visit for the pre-test session prior to the badminton training program. Upon arriving, in order to eliminate the effect of emotion (Coan and Allen 2003, Woodman *et al*. 2009), each participant was requested to sit quietly and watch a 5-min National Geographic (i.e. neutral) video to eliminate emotional disturbance before testing. Anthropometric measures (i.e. height, weight, waist circumference) and PAR-Q were used to screen for any health issues that could be made worse due to the badminton sport. Next, resting heart rate, resting blood pressure, and the neural brain activities with 30-second eye-closed were recorded. Lastly, the 6-minute walk test was also administered. As for Special Olympics Individual Badminton Skills Assessment, it was conducted the first and last day of the training sessions.

After the pre-test session, 14 participants with ID (10 males and 4 females) were assigned into the exercise group. They were enrolled into an adapted physical activity (APA) class for one credit hour. 8 young adults without ID with no badminton experience also participated as unified partners. The APA class was scheduled for 50-minute long each session, twice a week for the whole semester. In addition, 4 participants with ID (4 males) who did not to attend APA class and still volunteered to attend this study were asked to continue their daily school schedule as the control group. The Shuttle Time Badminton Starter lessons, an innovative training program designed by the Badminton World Federation (BWF), was delivered during the sport program. Shuttle Time offers 10 starter sessions aimed at individuals with little or no badminton experience. The instructor for these lessons had the necessary experience for teaching adults with and without ID and had attended a BWF training course to gain international certification. In order to practice 10 starter beginner lessons, participants with and without ID would practice in 50-min sessions, twice a week for 5 weeks. Each session consisted of warm-up exercises, badminton drill practice, and cool-down activities. All participants in each of the sessions were encouraged to perform the activities at a moderate exercise intensity with increased breath rate but not out of breath and light sweat.

After 5 weeks, each participant with ID was required to do a laboratory test as part of the post-test session. Participants visited at the same time schedule for pre-test session to avoid environmental effects (e.g. temperature, sunlight) on the results.

Measurements

Physiological functions

Resting heart rate (RHR) and blood pressure (BP)

RHR and BP were measured using a digital automated blood pressure monitor (OMRON-BP742N, OMRON, Matsuzaka, Mie, Japan) on the right upper arm. Readings were taken after 5 min of quiet seated rest.

Waist circumference

Waist circumference was measured across the belly button wearing light clothing and recorded to the nearest cm using a tape measure by trained researchers, with the participants standing and breathing normally.

Resting electroencephalographic (EEG) recording

EEG was assessed using the Emotiv EPOC system (U.S.A., 2011). The EPOC headset with flexible plastic arms equipped with gold-plated sensors was placed on each participant's head, in alignment with the international 10-20 system (Jasper 1958) . EEG was recorded from 7 sets of symmetric channels (F3/4, F7/8, Fp1/2, FC5/6, T3/4, P7/8, and O1/2); two rubber sensors were placed on mastoids (electrodes behind each ear) as references. A saline solution was applied to each sensor to ensure the signals from the brain adequately conducted. Good contact quality was achieved at each location, confirmed by the "green" color of the sensor circles in the Emotiv Test Bench program. During the recording, participants were required to sit still with eyes closed for 30 s and to avoid muscle movements as much as possible in order to reduce possible artifacts from eyeball movement, teeth clenching, and/or neck movement. The EPOC internally sampled at a frequency of 2048 Hz, which then gets down-sampled to 128 Hz sampling frequency per channel. The bandpass filter were 0-45 Hz digital notch filters. All data was transmitted wirelessly to the computer via Bluetooth.

Table 1. Descriptive statistics of participants.

	Exercise Group ($n = 14$)	Control Group ($n = 4$)	Z	p
Chronological Age (years)	22.36 ± 1.91	22.00 ± 1.82	-.27	.79
Height (cm)	167.41 ± 11.43	165.83 ± 7.98	-.44	.66
Weight (kg)	73.33 ± 16.28	64.67 ± 13.95	−1.01	.31
Body Mass Index (kg/m^2)	26.30 ± 5.99	23.36 ± 3.23	1.76	.45
# Females	4	0		

Motor performance

6-minute walk test (6MWT)

The 6MWT was conducted on a covered corridor with flat and hard surface. Participants were asked to stand by a start point facing a cone that was 25 meters away. A stopwatch was used to time the test. The instruction to walk as fast as possible was given before the test. Time measurements began when the researcher said, "go." Constant verbal encouragement, such as, "you are doing well," and "you have x minutes to go" were given to maintain motivation throughout the entire test. Walking distance was then calculated as the performance measure in this test. The test's predictive validity of work capacity and mobility in adults with ID was .65. The internal reliability of this methodology is reported to be .96 (Guerra-Balic *et al*. 2015).

Special Olympics Individual Badminton Skills Assessment

The Special Olympics Individual Badminton Skills Assessment was modified and adopted for this testing. The test battery comprised of 1) 30-second hitting up activity, i.e. the shuttle was repeatedly hit in the air and one point was awarded for each hit within a 30-second time frame; 2) Underarm stroke, i.e. five shuttles were hit high one at a time to the participant and one point was awarded when the shuttle was hit with an underarm stroke; 3) Overarm stroke, i.e. five shuttles were thrown one at a time to the participant like a dart would be thrown, and one point was awarded when the shuttle was hit; 4) Forehand stroke, i.e. five shuttles were thrown one at the time over the net to the right backhand stroke of the participant, and one point was awarded when the shuttle was hit successfully with a forehand stroke that goes over the net and in the court; and 5) Backhand serve, i.e. five attempts were given from either side of the service court and one point was given for each landing in the correct service box. The performance was measured based on points achieved within the given time to achieve success. Total soccer skill performance was computed by summing the points of these five specific skills.

Psychological measure

Zung Self-Rating Depression Scale (SDS)

Designed by Zung (1965) to assess the level of depression, the SDS is a short self-reported survey with 20 items that rate the pervasive effect, physiological equivalents, other disturbances, and the psychomotor activity perspectives of depression. The internal consistency of the scale for persons with ID was .58 (Powell 2003). Also, the results in SDS and the Beck depression scale showed significant correlation ($r = .35$) in individuals with ID (Helsel and Matson 1998). Thus, participants can reliably identify their own emotions on this scale. Each item was scored on a Likert scale ranging from 1 to 4. A total score was derived by summing individual item scores, and ranges from 20 to 80. Higher scores on this scale indicated more symptoms of depression but did not suggest that the participant would receive a clinical diagnosis of a major depressive episode.

Exercise Self-Efficacy Scale (ESES)

This scale is a modified version of Bandura's Exercise Self-Efficacy Scale (Bandura 1997). ESES involves a short self-reported survey with 9 items that assess self-expression confidence. Each item is scored on a Likert scale ranging from 1 to 4, where a score of 1 is not confident and 4 is very confident. Thus, this scale has a range of total scores from 9-36. The internal consistency of the scale was .88. People with higher scores are indicative of higher levels of self-efficacy in this exercise.

Data analysis

EEG activity in the alpha frequency band (8–13 Hz) is inversely related to activation of the underlying cortex (Oakes *et al*. 2004). Based on the valence motivation model, the dominant left relative to right frontal activation, also known as high frontal alpha asymmetry (FAA), represents an approach motivational system and positive affect (Davidson 2004). The FAA was calculated by subtracting the natural log-transformed alpha power in the left frontal region (F3, F7, Fp1) from the natural log-transformed power in the right frontal region (F4, F8, Fp2) (Coan and Allen 2003). One participant was eliminated for EEG analysis due to high impedance during pre-test recording.

Statistical analyses were conducted in SPSS 26 (SPSS Inc., Chicago, IL, USA). Considering insufficient power and violation of the assumption of normality due to the small sample size, the Wilcoxon signed-rank test was used. A Wilcoxon signed-rank test was also conducted for comparison purposes for each dependent measure between pre- and post-test sessions

Table 2. Comparisons between pre- and post- badminton training in exercise and control groups.

	Exercise Group ($n = 14$)				Control Group ($n = 4$)			
	Pre	Post	Z	p	Pre	Post	Z	P
Physiological Function								
HR (bpm)	84.29 ± 15.57	77.36 ± 17.40	−2.01	0.04*	88.00 ± 20.05	89.00 ± 16.83	.00	1.00
SBP (mmHg)	116.64 ± 11.65	116.50 ± 11.55	−0.03	0.97	117.25 ± 11.59	122.50 ± 14.20	−1.10	0.27
DBP (mmHg)	72.29 ± 9.41	73.93 ± 9.03	−0.38	0.71	79.50 ± 7.42	75.50 ± 8.27	−1.34	0.18
BMI (kg/m^2)	26.30 ± 5.99	25.66 ± 6.07	−1.48	0.14	23.36 ± 3.24	25.12 ± 4.77	−1.07	0.29
FAA	0.06 ± 0.45	0.34 ± 0.27	−2.27	0.02*	0.26 ± 0.14	0.50 ± 0.22	−1.83	0.07
Motor Performance								
6MWD (m)	515.89 ± 62.76	560.79 ± 6.24	−2.73	0.006*	564.20 ± 74.41	584.83 ± 28.77	−0.73	0.47
Badminton Skill	18.93 ± 72.5	25.07 ± 10.47	−2.83	0.005*	12.00 ± 4.24	19.00 ± 11.05	−1.60	0.11
Psychological Measure								
Zhung Depression	40.86 ± 6.94	37.79 ± 6.24	−1.86	0.06	29.75 ± 3.87	29.50 ± 3.32	0.00	1.00
ESE	21.29 ± 6.44	19.93 ± 5.33	−0.28	0.77	22.25 ± 6.71	20.46 ± 5.14	−0.92	0.36

Note. HR = Heat rate; SBP = Systolic blood pressure; DBP = Diastolic blood pressure; BMI = Body mass index; 6MWD= 6-min walking distance; FAA = Frontal alpha asymmetry; ESE = Exercise self-efficacy.
*$p < 0.05$.

in the exercise and control groups, respectively. This non-parametric test is similar to the parametric paired t-test in which the median values were used.

Results

Physiological function

As seen in Table 2, the resting heart rate (RHR) was significantly lowered in the exercise group from pre-test ($M = 84.29 \pm 15.57$ bpm) session to post-test ($M = 77.35 \pm 17.39$ bpm) session: $Z = -2.01$, $p = 0.04$, r = −0.54. No significant changes were found in body mass index (BMI): $Z = -1.48$, $p = 0.14$, r = −0.40, systolic blood pressure: $Z = -0.03$, $p = 0.97$, r = −0.01, and diastolic blood pressure: $Z = -0.38$, $p = 0.71$, r = −0.10. Further, the FAA was computed by comparing the difference between alpha brain frequency power in the left frontal region and right frontal region. The participants significantly expressed higher FAA score from pre-test ($M = 0.06 \pm 0.45$) session to post-test ($M = 0.34 \pm 0.27$) session: $Z = -2.27$, $p = 0.02$, r = −0.61.

In the control group, no significant changes were indicated in RHR: $Z = 0.00$, $p = 1.00$, r = −0.54, $r = 0.00$, BMI: $Z = -1.07$, $p = 0.29$, r = −0.54, systolic blood pressure: $Z = -1.10$, $p = 0.27$, r = −0.55, and diastolic blood pressure: $Z = -1.34$, $p = 0.18$, r = −0.67 and FAA score: $Z = -1.83$, $p = 0.07$, r = −0.92.

Motor performance

Table 2 shows that the exercise group walked significantly longer distances in 6-min walk test (6MWT) from pre-test ($M = 515.89 \pm 62.76$ m) session to post-test ($M = 560.79 \pm 66.93$ m) session: $Z = -2.73$, $p = 0.006$, $r = 0.73$. The exercise group also performed more points in Special Olympics Individual Badminton Skills Assessment, from pre-test ($M = 18.93 \pm 7.25$ points) session to post-test ($M = 25.07 \pm 10.37$ points) session: $Z = -2.83$, $p = 0.005$, r = −0.76.

However, the control group showed no significant changes in 6MWT: $Z = -0.73$, $p = 0.47$, r = −0.37, and Special Olympics Individual Badminton Skills Assessment: $Z = -1.60$, $p = 0.11$, r = −0.80.

Psychological measure

Table 2 also shows that exercise did not have substantial reduction in the scores of Zung self-rating depression scale (SDS), from pre-test ($M = 40.86 \pm 6.94$ points) session to post-test ($M = 37.79 \pm 6.24$ points) session: $Z = -1.86$, $p = 0.06$, r = −0.50, as well as no significant reduction in the scores of ESES: $Z = -0.28$, $p = 0.77$, r = −0.07.

Similarly, the control group showed no significant reduction in the scores of SDS: $Z = 0.00$, $p = 1.00$, $r = 0$, and ESES: $Z = -0.92$, $p = 0.36$, r = −0.46.

Discussion

The purpose of this study was to explore the effect of an inclusive badminton training program on health and wellness in young adults with ID. This study suggested that after practicing Shuttle Time Starter Lessons with unified partners, the reduction in resting heart rate and the improvement in 6-min walk test and Special Olympics Individual Badminton Skills Assessment were noted in the exercise group. In addition, this was the first study that measured the neural asymmetry responsiveness toward a short-term sport training program among young adults with ID. The exercise group significantly expressed the increased high FAA after the training program. Moreover, this positive affectivity may correspond to the decreased scores in self-reported depressive symptoms in exercise group.

Accumulated evidence has shown the benefits of exercise in adults with ID (Baran *et al.* 2013, Chen *et al.* 2019, Rosegard *et al.* 2001). In this study, which extended previous findings, we aimed to investigate improvements in overall health and wellbeing after the Shuttle Time Starter Lessons. Consistent with the previous study on sedentary women (Jurca *et al.* 2004), badminton training slowed RHR that might be associated with a decrease in the intrinsic heart rate (HR) via mechanisms that have yet to be understood fully in individuals with ID. Furthermore, if the heart can work less to pump, the force on arteries decreases, lowering blood pressure (BP). However, no effect of badminton training on either systolic blood pressure or diastolic blood pressure was seen in the present study. Cornelissen and Smart (2013) conducted a meta-analysis and indicated the most significant reduction in BP was evident among hypertensive patients. Also, endurance training, dynamic resistance training, and isometric resistance training yielded a significant reduction in BP. In the present study, however, the exercise group seemed to have normal BP during pre-test session, so their resting BP may not have changed easily. Also, the rate of perceived exertion, HR and even BP was not monitored during training. Therefore, although the exercise group was encouraged to maintain moderate exercise intensity with their typical peers each time, the intensity of exercise may not have been sufficient to have a significant effect on BP.

The cortical hemispheric differences are a result of the positive or negative valence of emotional conditions representing a current affective state. This physiological change mediated by the communication of the hypothalamic-pituitary-adrenal (HPA) axis is probably with several regions of the brain, including the limbic system, which controls motivation and mood; the amygdala, which generates fear in response to stress; and the hippocampus, which plays an important part in memory formation as well as in mood and motivation. To date, the association between the activity of HPA axis and the lateralized brain activity (Davidson 2004). The positive emotion is related to more left frontal activity relative to right. However, this is inconsistent as reported by Chen *et al*. (2016) in laboratory settings, where participants with ID expressed a decrease in FAA after a 20-min treadmill walk. The purpose of Shuttle Time Lessons is to provide the knowledge and deliver fun, safe, and enjoyable badminton lessons. The inclusive setting also promotes additional friendship development with participants without disabilities. Participants with ID were all assigned a college coach to assist in their learning at the university. Since the significant increase was not evident in the control group, this additive inclusive sport experiences might be the reasons why the exercise group showed a significant increase in FAA after the badminton training program. In particular, age and sex could be the critical variables for the association between FAA and emotion (Palmiero and Piccardi 2017). The Spearman's rank correlation in the present study demonstrated a negative association in the changes between pre- and post-FAA recordings and the changes in Zung self-rated depression scale (SDS) scores after controlling for age and sex variables ($r =$ .55, $p = 0.03$). Participants who reported lower scores in SDS expressed higher left FAA. Thus, the present study extends the investigation to persons with ID and supports the ideas that the affective response in relation to FFA may be predictive of affective response in persons with ID.

As for motor performance measures, 6-min walk test (6MWT) has been a valid and reliable measurement tool to assess physical fitness levels in people with ID (Elmahgoub *et al*. 2012). The distance in 6MWT was significantly correlated with maximal oxygen consumption (Burr *et al*. 2011). Hence, the improved cardio function may explain why the exercise group had lower RHR after the badminton training. 6MWT also provides a good measure of mobility and balance. During badminton training, the exercise group was required to perform running, lunging, diving, and shuttle cock hitting. Thus, physical training in low extremities may promote the improvement in walking distance of 6MWT. Overall, it was evident that the exercise group improved basic badminton skills as well as mobility. Therefore, Shuttle Time Starter Lessons could be considered in future Special Olympics and local school sport training programs for students with special needs. In the future, a larger sample size and longer training time should be considered to evaluate the long-term effect of shuttle time curriculum.

From a psychological perspective, contrary to a recent study, the mean scores in ESES were not significantly increased (Jo *et al*. 2018). Jo *et al*. (2018) assessed two domains of exercise self-efficacy, perceived physical competence and physical self-expression confidence, and found that after the 12-week exercise program, a significant difference was observed in the domain of perceived physical ability, but not in physical self-presentation confidence. In the present study, exercise self-efficacy was to assess the individual's belief to carry out the exercise behavior in difficult situations (e.g. having schoolwork due, at home, during travel). The practice time was determined in order to accommodate each participant's study schedule. Thus, such program experience may not be sufficient to increase self-efficacy level that could overcome various internal or external environmental barriers in daily lives among participants with ID. Critically, according to a research on the path to physical activity participation in adults with ID, social support was a strong predictor of physical activity participation (Peterson *et al*. 2008). That is, providing social support for adults with ID through well-planned sports programs could promote exercise adherence in this population, and it could lead to increased self-efficacy. Participants with ID only had the opportunity to practice badminton together with participants without disabilities during the program practice. Hence, the social support and functioning may not be sufficiently addressed. In order to promote health and wellness in this population, future studies and interventions are recommended to include support from family members, residential staff, and peers with and without disabilities.

Exercise seems to improve depressive symptoms in people with depression when compared with control groups (Dunn *et al*. 2005, Ströhle 2009). However, there are only few studies that focus on persons with ID. Carraro and Gobbi (2014) conducted a 12-week exercise training program for adults with ID, where participants practiced two times a week in one-hour sessions of group-based exercise. They found statistically significant reductions in SDS scoring for the exercise group compared with the control group after a 12-week exercise training regimen. Similarly, in the present study, the mean of the scores was reduced by 1.36 points after a 5-week badminton training program; yet, the mean scores in the control group were only reduced by 0.25 points. Therefore, it could be assumed that the length of the badminton training in this project may not be long enough to reach a significant psychological benefit that participants would perceive. Our results only partially supported the hypothesis of the direct benefits between exercise and mental health in people with ID.

A number of remarks should also be made about external validity. These remarks relate to the sample size, age of the participants, and the setting in which the study was conducted. The present study included a convenience sample as a control group consisting of people of similar ages with mild to moderate levels of ID. However, the numbers of participant in exercise and control groups were not equally distributed. Thus, the study sample size was not enough for multilevel analysis. In addition, all were living in a university residential setting. This limits the extent to which the results of the current study can be generalized to children and aging populations with severe symptoms and to other living environments such as small-scale facilities or home settings. The current study's sample, however, was too small to include other factors that might be associated with badminton learning. Furthermore, future studies may consider adding another segregated exercise group for persons with ID to clearly clarify the effect of inclusion on health and wellbeing in this population. Additionally, longer practice sessions and advanced materials might be introduced. Exercise HR and rate perceived exertion (RPE) should be considered to define intensity of exercise in a future study even though participants were encouraged to be physically active and subjective observation was made during badminton practice. Moreover, it is recommended that future studies also include hormonal or neural measures to identify the potential role of the relationship between exercise and mental health. Further studies are needed to elaborate on these issues mentioned above.

In summary, the findings of this study shed light on inclusive badminton training as a natural way to improve health and wellbeing in individuals with ID in addition to laboratory settings. Parents, teachers, and coaches could adopt Shuttle Time Starters Lessons to train their children and students. Badminton is not only a physical activity designed for improving physical and motor elements but suitable for promoting mental health. In such activities, badminton might affect the development of mental health through the activation of frontal brain activity. However, future research is still needed to further examine the current findings with additional control group, larger sample sizes, and employing more psychophysiological measures (e.g. exercise HR, neural activation, hormonal levels) to further explore the mechanisms in the relationship between exercise and health in people with ID.

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Conflict of interest

The authors have no conflicts of interest to declare in reference to this work.

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