Impact of Frisbee game course on the upper limb motor function of students with intellectual disabilities

Ming-Sui Kao, Chen-Hsuan Wang

Department of Adapted Physical Education, National Taiwan Sport University, Taoyuan, Taiwan

Objectives: Upper limb motor dysfunction often occurs in individuals with intellectual disabilities, affecting their daily self-care abilities and employability. Therefore, enhancing their upper limb motor function could improve the quality of life. This study investigated the impact of Frisbee game course on the upper limb motor function of students with intellectual disabilities.
Methods: A self-designed Frisbee game course was made available to 10 senior vocational students with moderate to severe intellectual disabilities in a special school in New Taipei City, Taiwan. The students participated 40 min each time, 4 times a week, for 6 weeks. Pre and post-test functional capacity and Frisbee throwing distance were measured. Descriptive statistics and paired-sample t-test were performed for the data analysis.
Results: Frisbee game course improved the lifting capacity, significantly improved the grip strength (dominant hand), upper limb power, hand-eye coordination, and gross and fine hand motor skills of students with intellectual disabilities.
Conclusion: Frisbee game course can improve upper limb muscle strength, power, coordination ability, and dexterity. Schools should implement Frisbee game courses and ensure their availability in the health and physical education of students with intellectual disabilities to enhance their upper limb motor function, employability, and vocational adaptability, thus improving their quality of life.

Keywords: hand-eye coordination, motor skills, adapted physical education

Introduction

Students with intellectual disabilities accounted for 24.8% of all students from pre-school to high school age, comprising the second-largest group of students with physical or mental disabilities only next to learning disabilities in Taiwan (Special Education Transmit Net 2015). Impairment of motor skills is widespread in individuals with intellectual disabilities since intellectual disabilities is a condition of deficient brain development, which affects the cognitive as well as the motor functions (Giagazoglou *et al.* 2012; Hartman *et al.* 2015; Westendorp *et al.* 2011). Upper limb motor skills, such as fine and gross motor, coordination, and accuracy skills, are highly important for our ability to manage and succeed in everyday life (Cook and Woollacott 2012). People with even mild intellectual disabilities showed deficits in fine motor and gross motor control of the upper limbs, as well as slower reaction time compared with age-matched controls who did not have intellectual disabilities (Carmeli *et al.* 2008). Individuals with intellectual disabilities have few opportunities to use their hands or fingers and to stretch and bend their arms. This leads to poor operational capacities for grasping, holding, throwing, and similar functions as well as the tendency to display hand dysfunction (Fait 1978). Furthermore, their visual motor control, balance, upper limb motor function, speed, and dexterity are the weakest during motor development (Carmeli *et al.* 2008; Ho 2009; Jankowicz-Szymanska *et al.* 2012). These deficiencies in upper limb motor function, in turn, affect their employment or job performance success (Bolton *et al.* 2000). The survey report also pointed out that a lack of job skills is one of the major reasons for dismissal or resignation in individuals with intellectual disabilities (Ministry of Labor, Executive Yuan 2014). However, most jobs performed by individuals with intellectual disabilities require upper limb motor skills (Wu 2007). The corresponding motor skills are a prerequisite for the integration of a person with intellectual disabilities in everyday life, to deal with activities of daily living, and in particular for the integration into work, because this group of people usually works in manual professions (Pavel *et al.* 2012). Therefore, to maintain good upper limb function, the integration of muscle strength, movements, hand coordination, dexterity, and other body structures not only enable the effective implementation of daily activities but also

Correspondence to: Chen-Hsuan Wang, Department of Adapted Physical Education, National Taiwan Sport University, No. 250, Wenhua 1st Rd., Guishan, Taoyuan 33301, Taiwan. Email: hsuan@ntsu.edu.tw

DOI 10.1080/20473869.2016.1267302

increase their employment opportunities and vocational performance (Chen and Chang 1999; Frey *et al.* 2008), and further improve the quality of life (Flores *et al.* 2011).

Students with intellectual disabilities often face restricted sports participation (Birrer 2004; Durstine *et al.* 2009) and are unable to perform intense physical activities (Downs 1995; Mâsse *et al.* 2012) due to challenges including abnormal balance; inadequate muscle strength, coordination, and motor response; and other comorbidities (e.g. epilepsy, cerebral palsy, and other sensory impairments) (Reichard *et al.* 2011). Research has also shown that students with intellectual disabilities tend to participate in static physical activities (King *et al.* 2013; Sit *et al.* 2007). The coordination, movement integration, balance, and learning ability of individuals with intellectual disabilities are relatively weaker, which leads to their inability to perform delicate, highly skilled movements or complete multiple complicated actions (Carmeli *et al.* 2008). Nevertheless, after exercise intervention, limb, coordination, attention, and other capabilities have been shown to improve significantly (Frey *et al.* 2008; Ko 2013). One study also indicated that students with intellectual disabilities who participated in woodball showed improved physical activity levels and improved learning of motor skills, social behaviors, and concentration (Shang 2002). Furthermore, participating in adapted physical activities improved the performances of individuals with intellectual disabilities in the areas of vision, upper limb speed and coordination, movement control capacity, dexterity, bilateral coordination, balance, and strength, among others (Hou *et al.* 2009; Top 2015; Top *et al.* 2015).

Exercise not only helps improve the physical and psychological characteristics of students with physical and mental disabilities and promote peer interactions, it also contributes to their social integration and enhances their ability to adapt to social life (Carraro and Gobbi 2012; Shang 2010; Vogt *et al.* 2012). In addition, school physical education programs play a very important role in developing exercise habits as well as the planning of recreational exercise and physical activities of students with intellectual disabilities (Brusseau *et al.* 2013). Transforming simple exercise into lifestyle factors is not only beneficial for improving health and enhancing physical coordination, it also indirectly encourages students with intellectual disabilities to interact with their community (Queralt *et al.* 2016). Such interactions will boost their self-confidence and increase their contact with society and the environment, thereby helping them achieve holistic physical and mental health (Carraro and Gobbi 2012; Chang and Lin 2008; Vogt *et al.* 2012). Regular exercise enables individuals with intellectual disabilities to prevent second-order barriers, improve their quality of life, cultivate future employability, establish networking opportunities, enhance their self-esteem and confidence, improve their mental health, overcome environmental barriers, and improve their economic situation (Chen and Chou 2012). Improved physical fitness and elevated skill level gained during exercise and sport activities appear to serve as mediators for increased perceptions of self-efficacy and social competence (Hutzler and Korsensky 2010). All above means that exercise is important for intellectually disabled individuals, improving the quality of life and a general well-being (Bartlo and Klein 2011; Cowley *et al.* 2010; Top 2015).

For students with intellectual disabilities, senior vocational education is the key to their transition from students to adults in the community (Chen and Zhang 2003). Such training helps them enhance their employment readiness and enables their rapid adaptation and integration into society, the main goal of this life stage (Moore and Schelling 2015). One study indicated that students with intellectual disabilities tended to undertake the following seven jobs after graduating from senior vocational school: janitor, bakery assistant, assembler, kitchen assistant, car washing assistant, supermarket assistant, and packer (Wu 2007). However, these seven jobs require good upper limb motor skills, such as ambidexterity, reaching, holding, grasping, grabbing, and similar motions (Pavel *et al.* 2012; Wu 2007). Exercise can improve the motor skills of individuals with physical and mental disabilities, thereby assisting them to maintain their ability to live independently and perform work-related tasks (Horvat *et al.* 2003; Top 2015). Therefore, if the upper limb motor functions of students with intellectual disabilities can be enhanced through exercise interventions, it will greatly benefit them in school, family life, and even future employment.

Considering the physical and psychological characteristics of students with intellectual disabilities, attention should be paid to the following items in the planning and design of their physical activities (Sherrill 2004; Tsai 2013; Winnick 2011): choosing their favorite games and sports and integrating opportunities for games or peer interactions to increase their physical activity levels; choosing relatively large, light, simple, and relatively risk-free sport equipment to ensure successful training completion and enhance self-confidence; limiting the number of participants to ensure that everyone can fully participate in the activities; and ensuring that physical activities are interesting and that teaching demonstrations are more than verbal but not oversimplified so the students do not feel challenged, are distracted, preventing achievement of the teaching aims. This study suggested that Frisbee games meet the above requirements to a large extent. Running, jumping, throwing, and other actions can be freely added to Frisbee games. It is also an interesting and fun activity for all ages (Chen 2013). In addition, a Frisbee game requires a small space, Frisbee, and playmate (Wang and Chen 2013). A Frisbee game is also able to help individuals develop hand-eye coordination and throwing ability (Lu 2010), as well as improve direction control coordination (Yang and Scholz 2005). In addition to improving hand-eye coordination, dexterity, reaction, and physical adaptive function, Frisbee throwing improves vision, which helps maintain mental clarity and achieve learning progress, thereby fulfilling several purposes and reaping numerous benefits (Yang 2014). However, there are limited studies on the impact of Frisbee teaching interventions in students with intellectual disabilities; furthermore, the research subjects were usually elementary school students and the assessments were not focused on upper limb motor skills (Lu 2010; Wang 2013). Therefore, this study focused on students in senior vocational school with moderate to severe intellectual disabilities to explore the impact of Frisbee playing on upper limb motor function to further understand whether Frisbee playing is beneficial to the employment readiness of students with intellectual disabilities.

Method

Participants

Purposive sampling was performed in this study. Ten students with moderate to severe intellectual disabilities (10 boys; mean age ± SD, 17.5 ± 0.17 y) in the second and third year of the senior vocational level were selected as subjects from a special school in New Taipei city. Participants were excluded from the study if they were unable to attend the exercise training program and tests, if they had any underlying health condition that would prevent them from participation, or if they were taking part in any other training programs. Prior to the experiment, the parents, teachers, and students were informed of the study's purpose, experimental methods, potential risks, and related precautions. The experiment only proceeded after the parents (guardians) signed the consent form.

Study design

This study used a single-group pre-test–post-test design. A self-designed Frisbee game course was used as the teaching content of a 6-week teaching intervention with a frequency of four times a week for 40 min each time (including warm-up, main exercise, and cool-down) and a total of 24 lessons. The teaching content covered the basic movements of Frisbee throwing and catching. In addition, throwing distance, throwing accuracy, rotation, and other skills were also integrated with game concepts for teaching activities. The 'National Taiwan University Hospital Functional Capacity Evaluation' (Jang *et al.* 2009; Zhang *et al.* 2005) and Frisbee distance throwing (Huang 2011; Wang 2012) were evaluated before and after the 6-week teaching intervention to elucidate the impact of Frisbee game course on the upper limb motor function of senior vocational students with intellectual disabilities.

Research tools

National Taiwan University Hospital functional capacity evaluation

This test is a Taiwanese functional capacity evaluation tool based on the 20 basic physical capacities for work listed in the American Dictionary of Occupational Titles that was developed with reference to common functional capacity evaluation methods (Jang *et al.* 2009; Zhang *et al.* 2005). It is commonly used to assist the evaluation of the return to work or employment process of workers with injuries and disabilities.

In Taiwan, when third-year students with intellectual disabilities in senior vocational education apply for vocational rehabilitation services from the Labor Affairs Council, this evaluation is an important tool often used by career counseling evaluators to assess whether individuals with intellectual disabilities possess the functional capacity for employment and function as a reference in job matching for individual cases. The evaluation items include sub-tests such as movement and balance, load capacity, hand function, and posture transition.

This study focused on upper limb motor skills; hence, only some of the test items were evaluated. The required evaluation tools and implementation methods were performed in accordance with the 'National Taiwan University Hospital functional capacity evaluation' operation manual. The evaluation items and methods are as follows:

Two-handed load lifting — ground to waist (ground → knuckle level). Students stood with their feet shoulder width apart, knees slightly bent, and hands and elbows straight and then grasped the moving crate. The crate was lifted from the ground to a shelf at the student's waist level (knuckle height) and then from the waist level and placed on the ground (one cycle). A 5-kg crate was used as the starting weight. If the student could successfully complete the cycle, 2.5-kg increments were added. The students' postures and facial expressions were observed during the test, and their feelings were inquired verbally to determine whether their maximum weight had been reached. The results were recorded in kilograms.

Two-handed load lifting — waist to chest (knuckle → three shelves below the shoulder). Students stood with feet shoulder width apart, knees slightly bent, and hands and elbows straight and then grasped the moving crate. The crate was lifted from the student's waist level to a shelf at their chest level and then the crate was lifted from the chest level and placed on the original shelf (one cycle). A 5-kg crate was used as the starting weight. If the student could successfully complete the cycle, 2.5-kg increments were added. The students' postures and facial expressions were observed during the test, and their feelings were inquired verbally to determine whether their maximum weight had been reached. The results were recorded in kilograms.

Grip strength of the dominant/non-dominant hand. Students were tested in a sitting position with their elbows bent at 90°, upper arm kept close to the body, and forearm in the middle position. The dominant and non-dominant hands were tested alternately three times each, and the average of three times was obtained. The results were recorded in kilograms.

Minnesota Manual Dexterity Test — dominant hand placing. Students were in a standing position and sequentially placed blocks into the holes of the test board. A stopwatch was used for timing. The subjects were required to practice once and were then tested twice, and the two test scores were added. The results were recorded in seconds.

Minnesota Manual Dexterity Test — two-hand turning. Students were in a standing position. They were asked to pick up blocks from the board with their left hand, pass it to their right hand to be turned, and return them to the original positions. A stopwatch was used for timing. The subjects were required to practice once and then tested twice, and the two test scores were added. The results were recorded in seconds.

Minnesota Manual Dexterity Test — dominant hand displacing. Students were in a standing position and displaced all of the blocks with their dominant hand based on the instructions for displacement methods in the operation manual. A stopwatch was used for timing. The subjects were required to practice once and then tested twice, and the two test scores were added. The results were recorded in seconds.

Minnesota Manual Dexterity Test — dominant hand turning and displacing. Students picked up the blocks in sequence from the board with their dominant hand, turned them, and placed them into the holes of another board. A stopwatch was used for timing. The subjects were required to practice once and then tested twice, and the two test scores were added. The results were recorded in seconds.

Minnesota Manual Dexterity Test — two-hand turning and displacing. Students picked up blocks in sequence from the board with two hands at the same time, turned them, and placed them in the holes of another board. A stopwatch was used for timing. The subjects were required to practice once and then tested twice, and the two test scores were added. The results were recorded in seconds.

Purdue Pegboard Test — dominant hand. Students were in a sitting position, given 30 s to sequentially insert metal pegs into holes with their dominant hand as quickly as possible, and stopped when the time was up. The number completed was calculated. The test was conducted three times, and the average of the three times was obtained. The results were recorded in number of metal pegs.

Purdue Pegboard Test — non-dominant hand. Students were in a sitting position, given 30 s to sequentially insert metal pegs into holes with their non-dominant hand as quickly as possible, and stopped when the time was up. The number completed was calculated. The test was conducted three times, and the average of the three times was obtained. The results were recorded in number of metal pegs.

Purdue Pegboard Test — both hands. Students were in a sitting position, given 30 s to take metal pegs from two trays placed on either side of them and insert them sequentially from top to bottom into holes using both hands simultaneously as quickly as possible, and stopped when time was up. The number of completed pairs was calculated. The test was conducted three times, and the average of the three times was obtained. The results were recorded in number of pairs.

Purdue Pegboard Test — assembly. Students were in a sitting position and asked to take and insert a small metal peg into the upper right hole with the dominant hand, followed by taking and placing a spacer onto the metal peg with the non-dominant hand, taking and placing a small metal collar onto the metal peg with the dominant hand, and taking and placing a spacer onto the metal peg with the non-dominant hand. This completes an assembly. During the process, each step was completed in sequence and the steps could not be skipped. One component was counted as one point; a completed assembly was four points. If there was an incomplete last group, the number of completed components was scored. The test time was 1 min. The subjects stopped when the time was up, and the scores were then calculated. The test was conducted three times, and the average of the three times was calculated. The results were recorded in number of points.

Frisbee throwing distance

Ball throwing distance is a common test of the power of the upper limbs (Huang 2011; Wang 2012). This study used Frisbee throwing distance as an evaluation tool of the power of the upper limbs. Subjects stood behind a line and threw a Frisbee one at a time. At the instant the Frisbee was thrown, the subject could not cross or step on the line. Up to five Frisbees could be thrown. The Frisbee throwing distances were measured with a measuring tape, and the best score was recorded. The results were recorded in meters.

In overall, the evaluation tools being applied in the study were listed in Table 1.

Data analysis

Statistical software SPSS for Windows version 18.0 was used to perform the descriptive statistics and paired-sample t-test on the data. The significance level for statistical testing was $\alpha = .05$. In addition, the effect size (ES) was used to test the intervention effectiveness of the Frisbee game course on upper limb motor function. The ES formula was: (mean of post-test — mean of pre-test)/

Table 1 A summary of evaluation tools

Item	Tool/ Description
Load lifting capacity	Standardized five-repetition/weight test at increasing weight increments
Ground to waist	
Waist to chest	
Strength	Hand-grip dynamometer
Dexterity	
Gross arm-hand dexterity and Hand-eye coordination	Minnesota Manual Dexterity Test — placing, turning, and displacing
Gross dexterity of the arm, hand, and fingers	Purdue Pegboard Test — dominant/non-dominant hand and both hands
Fine dexterity of fingertips	Purdue Pegboard Test — assembly
Power	Frisbee throwing

Table 2 Effect of Frisbee game course on two-handed load lifting

	Mean (standard deviation)				
Item	Pre-test	Post-test	*t* value	*p* value	Effect size
Two-handed load lifting — ground to waist (kg)	19.10 (4.88)	21.00 (5.73)	–1.90	.09	.36
Two-handed load lifting — waist to chest (kg)	15.90 (2.75)	17.45 (3.32)	–1.87	.09	.50

Table 3 Effect of Frisbee game course on grip strength

	Mean (standard deviation)				
Item	Pre-test	Post-test	*t* value	*p* value	Effect size
Grip strength of the dominant hand (kg)	18.26 (4.87)	21.69 (4.28)	–2.86	.02*	.75
Grip strength of the non-dominant hand (kg)	18.22 (6.18)	19.89 (3.27)	–1.37	.21	.34

*$p < .05$.

Table 4 Effect of Frisbee game course on power

	Mean (standard deviation)				
Item	Pre-test	Post-test	*t* value	*p* value	Effect size
Frisbee throwing distance (m)	12.45 (3.31)	15.61 (3.30)	–2.75	.022*	.96

*$p < .05$.

(mean standard deviation of post-test and pre-test means); ES = 0.8 indicated a large effect; ES = 0.5 a medium effect; and ES = 0.2 a small effect (Cohen 1988, 1992).

Results

Effects of Frisbee game course on load lifting capacity

The results showed that post-test performances of two-handed load lifting (ground to waist) and two-handed load lifting (waist to chest) were superior to those of the pre-test performances (Table 2), but no significant difference was detected ($p = .09$). This finding indicates that the Frisbee game course slightly improved the two-handed load lifting capacity, but its benefits were limited.

Effects of Frisbee course participation on grip strength and upper limb power

In terms of grip strength (Table 3), that of the dominant hand had increased significantly ($p = .02$); the ES was 0.75. Grip strength of the non-dominant hand had also increased, but there was no significant difference ($p = .21$). Our results indicated that the grip strength of the dominant hand of senior vocational students with intellectual disabilities showed moderate improvement after Frisbee game course intervention. The grip strength of their non-dominant hand showed a slight increase, but the effect was not significant. Frisbee throwing distance after the 6-week teaching intervention increased significantly (Table 4), suggesting that the power in the students' upper limbs had improved significantly and achieved a large effect (ES = 0.96).

Effect of Frisbee course participation on hand-eye coordination and hand movements

The Minnesota Manual Dexterity Test (Table 5) results showed that for dominant hand placing, two-hand turning, dominant hand displacing, dominant hand turning and displacing, and two-hand turning and displacing, the post-test performances were all significantly better than the pre-test performances ($p < .05$), and the ES values were 0.59–0.89. As for the Purdue Pegboard Test (Table 6), performances in the dominant hand, non-dominant hand, two-hand, and assembly items of the post-test were significantly better than those of the pre-test ($p < .05$), and the ES values were 0.45–0.72.

Discussion

As mentioned in the introduction, individuals with intellectual disabilities tend to engage in jobs involving

Table 5 Summary of the differences in Minnesota Manual Dexterity Test

Item	Mean (standard deviation)		*t* value	*p* value	Effect size
	Pre-test	Post-test			
Dominant hand placing (second)	211.68 (39.87)	186.21 (34.94)	34.90	.00*	−0.68
Two-hand turning (second)	264.04 (49.65)	233.17 (60.79)	2.61	.03*	−0.56
Dominant hand displacing (second)	173.00 (33.32)	146.37 (25.83)	25.83	.00*	−0.89
Dominant hand turning and displacing (second)	262.11 (67.26)	221.64 (54.46)	54.46	.00*	−0.66
Two-hand turning and displacing (second)	279.35 (64.40)	242.44 (61.02)	3.05	.01*	−0.59

*$p < .05$.

Table 6 Summary of the differences in Purdue Pegboard Test

Item	Mean (standard deviation)		*t* value	*p* value	Effect size
	Pre-test	Post-test			
Dominant hand (pegs)	9.53 (2.25)	10.93 (1.66)	−3.88	.00*	0.71
Non-dominant hand (pegs)	8.70 (1.70)	10.23 (2.50)	−4.45	.00*	0.72
Both hands (pair)	7.18 (2.12)	8.22 (2.47)	−2.48	.04*	0.45
Assembly (point)	15.40 (6.43)	19.63 (8.23)	−5.06	.00*	0.57

*$p < .05$.

physical and unskilled labor, which require good physical strength and operating speed to fulfill job requirements, of which upper limb motor function is a very important component. A job analysis of individuals with intellectual disabilities revealed that transporting skills are often used (Chen *et al.* 2003) and that lifting accounts for the highest proportion of transporting patterns (Craig *et al.* 2013; Klein *et al.* 1984). By analyzing the seven jobs (janitor, bakery assistant, assembler, kitchen assistant, car washing assistant, supermarket assistant, and packer) that students with intellectual disabilities most commonly perform after graduating from senior vocational schools (Wu 2007), we found that lifting work occurred mostly below the chest level and included cardboard or material handling, lifting baking shelves, and so on. Based on the grading of physical capacity for employability from the 'National Taiwan University Hospital functional capacity evaluation' (Zhang *et al.* 2005), the load lifting capacity of our study subjects was moderate (9.1–22.7 kg), an average level among individuals with intellectual disabilities (Li and Chang 2002). The Frisbee course intervention improved the load lifting capacity of students with intellectual disabilities (from ground to waist and waist to chest), but the results were not significant. This may be because the course content involved full-body activities but did not focus on resistance or endurance training. Therefore, course intervention could not improve load lifting capacity as in other studies (Asfour *et al.* 1984; Rimmer and Kelly 1991; Smail and Horvat 2006; Shields *et al.* 2013).

Although the musculoskeletal development of individuals with intellectual disabilities showed no difference compared to that of the general population, their muscle strength was lower (Fernhall and Pitetti, 2000; Pitettia *et al.* 2013). In addition, muscle strength was positively correlated with intelligence (Golubovic *et al.* 2012; Londeree and Johnson 1974; Vuijk *et al.* 2010). For individuals with intellectual disabilities, muscle strength is an essential component for health, improving vocational productivity, and gaining independence in activities of daily living (Shields *et al.* 2010; Zetts *et al.* 1995). It has been reported that exercise is beneficial to hand grip strength in individuals with intellectual disabilities (Calders *et al.* 2011; Chen *et al.* 2014; Oviedo *et al.* 2014). This study also revealed that Frisbee game course significantly improved the muscle strength in the dominant hands of senior vocational students with moderate to severe intellectual disabilities but only slightly improved the muscle strength in the non-dominant hands. This was due to the movements of throwing and catching a Frisbee, which mainly depends on the dominant hand. This finding indicates that Frisbee game course significantly improved the hand grip strength of students with moderate to severe intellectual disabilities. The improvement of grip strength may ameliorate their work performance and functional capacity of daily living (Seagraves *et al.* 2004; Smail and Horvat 2006).

Muscle strength weakness has long been considered one of the primary impairments that contribute to activity limitation (Vinciguerra *et al.* 2010). Recent evidence suggests that other aspects of muscle performance, such as muscle power, are related to activity limitations and functional performance (Moreau *et al.* 2013). Power is the product of muscle strength and speed as well as the ability of the neuromuscular system to generate power in the shortest amount of time. Muscle strength, movement speed, coordination, motion perception, sense of timing, reaction time, and predictive ability are all factors that can affect power (Lin and Mai 2009). The upper limb power of the students (Frisbee throwing distance) increased significantly and reached a large ES. This finding is consistent with study from Wang (2013) who found that Frisbee game course can effectively promote the physical capacity of elementary school students with mild intellectual disabilities, especially in terms of muscle power. The muscle strength increase in these students contributes to the enhancement of power in their upper limbs (Stone *et al.* 2003). In addition, Frisbee can develop physical coordination, flexibility, balance, and reaction capability (Kung 2015; Lee 2015; Xiong and Zhu 1997). Therefore, the increase in upper limb power may also be associated with the factors mentioned above in addition to the increase in muscle strength.

Individuals with intellectual disabilities display problems with motor control, such as poor visual and motor coordination, difficulties with speed and accuracy of movements, distorted body sensibility, poor spatial orientation, balance problems, and difficulties in learning new skills (Carmeli *et al.* 2008; Jankowicz-Szymanska *et al.* 2012). After the Frisbee course intervention, the students' Minnesota Manual Dexterity Test results had improved significantly, reaching moderate to high ES levels, suggesting significant progress in their hand-eye coordination and gross hand motor skills. Similarly, the Purdue Pegboard Test results also showed significant progress and achieved a moderate ES, indicating that the students' fine hand motor skills had improved significantly. Most previous studies emphasized the effect of Frisbee sport on physical fitness of elementary school students (Liu 2015; Wang 2013) and fewer study discussed about the influence of dodgebee intervention on perceptual-motor skills (agility, static balance, dynamic balance, coordination ability and reaction ability) (Kung 2015). This study is the first paper to demonstrate that the Frisbee intervention is highly effective in improving hand motor skills and hand-eye coordination for senior high school students with intellectual disabilities. This result also verified that individuals with intellectual disabilities participated in planned exercise programs could ameliorate motor performance parameters (Frey *et al.* 2008), thereby improving their work efficiency and productivity (Shields *et al.* 2010, 2013; Zetts *et al.* 1995).

Although the present study provides evidence that the positive effect of Frisbee game course intervention on students with moderate to severe intellectual disabilities, it is acknowledged that there are limitations to the study. First, this study had a relatively small sample size of 10 participants and the sample came from only one special education school, therefore restricting the generalizability of our findings. Second, the present study used a single-group pre-test–post-test design. Other confounding factors may have affected the participants or the intervention.

Not only can employment enable individuals with physical and mental disabilities to achieve economic independence through employment, it can enhance their self-confidence and sense of accomplishment, increase their social interactions, and improve their life satisfaction. However, the unemployment rate of individuals with intellectual disabilities is higher than those of individuals in other categories of disabilities; in addition, the employment rate is inversely proportional to the level of disability (Ministry of Labor, Executive Yuan 2014). This study showed that a 6-week Frisbee game course significantly improved hand grip strength and power, hand-eye coordination, and gross and fine hand motor skills of the senior vocational students with moderate to severe intellectual disabilities and contributed to promoting their hand functions. Such improvements should help their future employment readiness, adaptability, and stability. The advantages of Frisbee game course in school teaching include low cost; low injury rate; suitability for a large population; and better comprehensive training effects for the body, hands, eyes, and brain compared with those of other sports (Xiong and Zhu 1997). Therefore, it is recommended that schools include a Frisbee game course when planning teaching activities for students with intellectual disabilities and adjust the difficulty of the movements (such as throwing, catching, spinning, rotating, and patting) or modify the game-related factors (such as throwing distance, throwing accuracy, dodging games, and Frisbee golf) to meet each student's ability level. Such offerings will increase course interest, enhance body function, and help students develop lifelong sports interests and abilities.

Acknowledgements

We thank all the students, their teachers and school for taking part in this study.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Asfour, S. S., Ayoub, M. M. and Mital, A. 1984. Effects of an endurance and strength training programme on lifting capability of males. *Ergonomics*, 27, 435–442. doi: 10.1080/00140138408963507.

Bartlo, P. and Klein, P. J. 2011. Physical activity benefits and needs in adults with intellectual disabilities: Systematic review of the literature. *American Journal on Intellectual and Developmental Disabilities*, 116, 220–232.

Birrer, R. B. 2004. The special olympics athlete: Evaluation and clearance for participation. *Clinical Pediatrics,* 43, 777–782.

Bolton, B., Bellini, J. and Brookings, J. 2000. Predicting vocational rehabilitation outcomes from applicants' personal history, functional limitations, and services provided. *Rehabilitation Counseling Bulletin*, 44, 10–21.

Brusseau, T. A., Kulinna, P. H., Tudor-Locke, C. and Ferry, M. 2013. Daily physical activity patterns of children living in an American Indian community. *Journal of Physical Activity and Health*, 10, 48e53.

Calders, P., Elmahgoub, S., Roman de Mettelinge, T., Vandenbroeck, C., Dewandele, I., Rombaut, L., Vandevelde, A. and Cambier, D. 2011. Effect of combined exercise training on physical and metabolic fitness in adults with intellectual disability: a controlled trial. *Clinical Rehabilitation*, 25, 1097–1108.

Carmeli, E., Bar-Yossef, T., Ariav, C., Levy, R. and Lieberman, D. G. 2008. Perceptual motor coordination in persons with mild intellectual disability. *Disability and Rehabilitation*, 30, 323–329.

Carraro, A. and Gobbi, E. 2012. Effects of an exercise programme on anxiety in adults with intellectual disabilities. *Research in Developmental Disabilities*, 33, 1221–1226.

Chang, Y. Y. and Lin, J. D. 2008. Healthy physical activities in people with intellectual disabilities: Facilitators and barriers. *Journal of Disability Research*, 6, 273–285.

Chen, Z. F. 2013. A review on influence of Frisbee on middle school students. *National Taipei University of Education Physical Education*, 7, 196–201.

Chen, C. C., Ringenbach, D. R. and Snow, M. 2014. Treadmill walking effects on grip strength in young men with Down syndrome. *Research in Developmental Disabilities*, 35, 288–293.

Chen, H. M. and Chang, J. J. 1999. The skill components of a therapeutic chopsticks task and their relationship with hand function tests. *The Kaohsiung Journal of Medical Sciences*, 15, 704–709.

Chen, J. R. and Chou, C. L. 2012. Physical fitness training for individuals with disabilities. *Special Education*, 123, 1–8.

Chen, L. J. and Zhang, D. 2003. Transition services in Taiwan: Comparison between service need and services received. *Education and Training in Developmental Disabilities*, 38, 334–340.

Chen, J. J., Wu, Y. Y., Wang, M. X., Su, C. Y. and Wu, M. Y. 2003. *Development of a work sample evaluation system for individuals with mental retardation* (Project No.: IOSH92-M143). Taipei: Institute of Labor, Occupational Safety and Health, Ministry of Labor, Executive Yuan.

Cohen, J. 1988. *Statistical power analysis for the behavioral sciences*. 2nd ed. Hillsdale, NJ: Erlbaum.

Cohen, J. 1992. A Power Primer. *Psychological Bulletin, 112*, 155–159.

Cook, A. S. and Woollacott, M. H. 2012. *Motor control: Translating research into clinical practice*. Philadelphia, PA: Lippincott Williams & Wilkins.

Cowley, P. M., Ploutz-Snyder, L. L., Baynard, T., Heffernan, K., Jae, S. Y., Hsu, S., Lee, M., Pitetti, K. H., Reiman, M. P. and Fernhall, B. 2010. Physical fitness predicts functional tasks in individuals with Down syndrome. *Medicine & Science in Sports & Exercise*, 42, 388–393. doi: 10.1249/MSS.0b013e3181b07e7a.

Craig, B. N., Congleton, J. J., Beier, E., Kerk, C. J., Amendola, A. A. and Gaines, W. G. 2013. Occupational risk factors and back injury. *International Journal of Occupational Safety and Ergonomics*, 19, 335–345.

Downs, P. 1995. *Willing and able: An introduction to inclusive practices*. Canberra: The Australian Sports Commission.

Durstine, J. L., Moore, G., Painter, P. and Roberts, S. 2009. *ACSM's exercise management for persons with chronic diseases and disabilities*. 3rd ed. Champaign, IL: Human Kinetics.

Fait, H. F. 1978. *Special physical education: Adapted, corrective, developmental* 4th ed. Philadelphia, PA: W. B. Saunders, pp.209–227

Fernhall, B. and Pitetti, K. H. 2000. Leg strength is related to endurance run performance in children and adolescents with mental retardation. *Pediatric Exercise Science*, 12, 324–333.

Flores, N., Jenaro, C., Orgaz, M. B. and Martín, M. 2011. Understanding quality of working life of workers with intellectual disabilities. *Journal of Applied Research in Intellectual Disabilities*, 24, 133–141.

Frey, G. C., Stanish, H. I. and Temple, V. A. 2008. Physical activity of youth with intellectual disability: Review and research agenda. *Adapted Physical Activity Quarterly*, 25, 95–117.

Giagazoglou, P., Arabatzi, F., Dipla, K., Liga, M. and Kellis, E. 2012. Effect of a hippotherapy intervention program on static balance and strength in adolescents with intellectual disabilities. *Research in Developmental Disabilities*, 33, 2265–2270.

Golubovic, S., Maksimovic, J., Golubovic, B. and Glumbic, N. 2012. Effects of exercise on physical fitness in children with intellectual disability. *Research in Developmental Disabilities*, 33, 608–614.

Hartman, E., Smith, J., Westendorp, M. and Visscher, C. 2015. Development of physical fitness in children with intellectual disabilities. *Journal of Intellectual Disability Research*, 59, 439–449.

Ho, H. K. 2009. *Education and psychology of exceptional children*. 4th ed. Taipei: Wunan.

Horvat, M., Eichstaedt, C., Kalakian, L. and Croce, R. 2003. *Development/adapted physical education: making ability count*. San Francisco, CA: Benjamin Cummings.

Hou, T. S., Ren, X. L. and Hou, J. Y. 2009. Effects of ball games on the movement capabilities of the intellectually disabled. *National Chiayi University Journal of Sports, Health and Recreation*, 8, 177–188.

Huang, Y. D. 2011. *The influence of Tchouk-Ball training on basic motor abilities in children* (unpublished master's thesis). Tainan: National University of Tainan.

Hutzler, Y. and Korsensky, O. 2010. Motivational correlates of physical activity in persons with an intellectual disability: A systematic literature review. *Journal of Intellectual Disability Research*, 54, 767–786.

Jang, Y., Chang, T. C. and Lin, K. C. 2009. Reliability and validity of a physical capacity evaluation used to assess individuals with intellectual disabilities and mental illness. *International Journal of Rehabilitation Research*, 32, 77–84.

Jankowicz-Szymanska, A., Mikolajczyk, E. and Wojtanowski, W. 2012. The effect of physical training on static balance in young people with intellectual disability. *Research in Developmental Disabilities*, 33, 675–681.

King, M., Shields, N., Imms, C., Black, M. and Ardern, C. 2013. Participation of children with intellectual disability compared with typically developing children. *Research in Developmental Disabilities*, 34, 1854–1862.

Klein, B. P., Jensen, R. C. and Sanderson, L. M. 1984. Assessment of workers' Compensation claims for back strains/sprains. *Journal of Occupational Medicine*, 26, 443–448.

Kung, I. L. 2015. *Effects of dodgebee teaching on developing perceptual-motor skill of primary school students* (unpublished Master's thesis). Tainan: National University of Tainan.

Ko, F.-H. 2013. Health problem of mental retardation due to lack of physical activities. *NTCUST Journal of Physical Education*, 9, 49–56.

Lee, T. W. 2015. *Effects of Dodgebee teaching on developing perceptual-motor skills of primary school students* (unpublished Master's thesis). Tainan: National University of Tainan.

Li, W. S. and Chang, T. C. 2002. *The development of a functional capacity evaluation and its application in job accommodation* (NSC 90-2614-002-004-47). Retrieved from National Taiwan University Institutional Repository website: http://ntur.lib.ntu.edu.tw/bitstream/246246/29923/1/902614B002004M47.pdf

Lin, Y. T. and Mai, C. Z. 2009. Exploring the training methods for agility in basketball. *University Physical Education & Sports*, 101, 131–138.

Liu, S. P. 2015. *A research on the relationship between Frisbee sport and physical fitness* (unpublished Master's thesis). Taichung: Asia University.

Londeree, B. R. and Johnson, L. E. 1974. Motor fitness for TMR vs. EMR and normal children. *Medicine and Science in Sports*, 6, 247–252.

Lu, C. F. 2010. The 'nine-squared Frisbee grid' — Exploring the physical education and education assessment of primary school special education classes. *Journal of Special Education,* 25, 55–62.

Mâsse, L. C., Miller, A. R., Shen, J., Schiariti, V. and Roxborough, L. 2012. Comparing participation in activities among children with disabilities. *Research in Developmental Disabilities*, 33, 2245–2254.

Ministry of Labor, Executive Yuan. 2014. 2014 labor force survey of individuals with mental or physical disability — Current labor status of disabled individuals. Available at: <http://statdb.mol.gov.tw/html/svy03/0342menu.htm>

Moore, E. J. and Schelling, A. 2015. Postsecondary inclusion for individuals with an intellectual disability and its effects on employment. *Journal of Intellectual Disabilities*, 19, 130–148.

Moreau, N. G., Holthaus, K. and Marlow, N. 2013. Differential adaptations of muscle architecture to high-velocity versus traditional strength training in cerebral palsy. *Neurorehabilitation and Neural Repair*, 27, 325–334.

Oviedo, G. R., Guerra-Balic, M., Baynard, T. and Javierre, C. 2014. Effects of aerobic, resistance and balance training in adults with intellectual disabilities. *Research in Developmental Disabilities*, 35, 2624–2634.

Pavel, Z., Barbora, Z. and Martina, T. 2012. Functional motor abilities of the upper extremities in children with mild intellectual disabilities. *Procedia-Social and Behavioral Sciences*, 69, 2068–2075.

Pitettia, K., Baynardb, T. and Agiovlasitisc, Stamatis 2013. Children and adolescents with Down syndrome, physical fitness and physical activity. *Journal of Sport and Health Science*, 2, 47–57.

Queralt, A., Vicente-Ortiz, A. and Molina-García, J. 2016. The physical activity patterns of adolescents with intellectual disabilities: A descriptive study. *Disability and Health Journal*, 9, 341–345.

Reichard, A., Stolzle, H. and Fox, M. H. 2011. Health disparities among adults with physical disabilities or cognitive limitations compared to individuals with no disabilities in the United States. *Disability and Health Journal*, 4, 59–67.

Rimmer, J. H. and Kelly, L. E. 1991. Effects of a resistance training program on adults with mental retardation. *Adapted Physical Activity Quarterly*, 8, 146–153.

Seagraves, F., Horvat, M., Franklin, C. and Jones, K. 2004. Effects of a school-based program on physical function and work productivity in individuals with mental retardation. *Clinical Kinesiology*, 58, 18–29.

Shang, I. W. 2002. Benefits of 'woodball' in students with intellectual disabilities. *University Physical Education & Sports*, 62, 143–145.

Shang, I. W. 2010. Application of cooperative learning theory on an adapted physical education course. *University Physical Education & Sports*, 106, 56–60.

Sherrill, C. 2004. *Adapted physical activity, recreation, and sport*. New York: McGraw-Hill.

Shields, N., Taylor, N. F. and Fernhal, B. 2010. A study protocol of a randomised controlled trial to investigate if a community based strength training programme improves work task performance in young adults with Down syndrome. *BMC Pediatrics*, 10, 17. doi: 10.1186/1471-2431-10-17.

Shields, N., Taylor, N. F., Wee, E., Wollersheim, D., O'Shea, S. D. and Fernhall, B. 2013. A community-based strength training programme increases muscle strength and physical activity in young people with Down syndrome: A randomised controlled trial. *Research in Developmental Disabilities*, 34, 4385–4394.

Sit, C. H. P., McManus, A., McKenzie, T. L. and Lian, J. 2007. Physical activity levels of children in special schools. *Preventive Medicine*, 45, 424–431.

Smail, K. M. and Horvat, M. 2006. Relationship of muscular strength on work performance in high school students with mental retardation. *Education and Training in Developmental Disabilities*, 41, 410–419.

Special Education Transmit Net. 2015. *Statistics of special education categories of students with disabilities in each county and city*. Available at: <https://www.set.edu.tw/Stastic_WEB/sta2/default.asp>

Stone, M. H., O'Bryant, H. S., McCoy, L., Coglianese, R., Lehmkuh, M. and Schilling, B. 2003. Power and maximum strength relationships during performance of dynamic and static weighted jumps. *Journal of strength and conditioning research*, 17, 140–147.

Top, E. 2015. The effect of swimming exercise on motor development level in adolescents with intellectual disabilities. *American Journal of Sports Science and Medicine*, 3, 85–89.

Top, E., Akkoyunlu, Y. and Akil, M. 2015. Analysis of the influence of a twelve-month swimming exercise on mentally disabled individuals' physical fitness level. *International Journal of Physical Education, Sports and Health*, 2, 315–322.

Tsai, C. L. 2013. Planning and design of physical activities for intellectual disabilities. *National Sports Quarterly*, 175, 57–61.

Vinciguerra, M., Musaro, A. and Rosenthal, N. 2010. Regulation of muscle atrophy in aging and disease. *Advances in Experimental Medicine and Biology*, 694, 211–233.

Vogt, T., Schneider, S., Abeln, V., Anneken, V. and Struder, H. K. 2012. Exercise, mood and cognitive performance in intellectual disability — A neurophysiological approach. *Behavioural Brain Research*, 226, 473–480.

Vuijk, P. J., Hartman, E., Scherder, E. and Visscher, C. 2010. Motor performance of children with mild intellectual disability and borderline intellectual functioning. *Journal of Intellectual Disability Research*, 54, 955–965.

Wang, W. J. 2013. *Effects of Frisbee course on the physical fitness of elementary school students with mild intellectual disabilities* (unpublished Master's thesis). Taoyuan: National Taiwan Sport University.

Wang, W. J. and Chen, Z. R. 2013. Citizens games sporting events-introduction of Frisbee. *Journal of Physical Education Fu Jen Catholic University*, 12, 203–213.

Wang, S. K. 2012. *Analysis on the effects of utilizing a basketball shooting machine on the athletic ability and set shooting rate in elementary school students* (unpublished master's thesis). New Taipei City: St John's University.

Westendorp, M., Houwen, S., Hartman, E. and Visscher, C. 2011. Are gross motor skills and sports participation related in children with intellectual disabilities? *Research in Developmental Disabilities*, 32, 1147–1153.

Winnick, J. P. 2011. *Adapted physical education and sport*. Champaign, IL: Human Kinetics.

Wu, C. H. 2007. An exploratory survey of the job requirements of employed graduates with intellectual disabilities in senior vocational high schools. *Rehabilitation Counselling*, 1, 17–46.

Xiong, W. Z. and Zhu, F. L. 1997. *Frisbee encyclopedia*. New Taipei City: Wuzhou.

Yang, H. F. 2014. Research on vision in elementary school special students. *Huei-Ming Journal of Special Education*, 1, 79–90.

Yang, J. F. and Scholz, J. P. 2005. Learning a throwing task is associated with differential changes in the use of motor abundance. *Experimental Brain Research*, 163, 137–158.

Zetts, R., Horvat, M. and Langone, J. 1995. The effects of a community-based resistance training program on the work productivity of adolescents with moderate to severe intellectual disabilities. *Education and Training in Mental Retardation and Developmental Disabilities*, 30, 66–78.

Zhang, Y., Li, W. S., Zhang, Z. Q., Jiang, Y. X. and Zhang, J. N. 2005. *Operation manual of the National Taiwan University Hospital functional capacity evaluation*. Taipei: Department of Occupational Therapy, National Taiwan University Hospital.