EFFECTS OF EXERCISE ON PHYSICAL FITNESS IN CHILDREN WITH INTELLECTUAL DISABILITY

Špela Golubović a, Jasna Maksimović b, Boris Golubović c,*, Nenad Glumbić d

a Faculty of Medicine, Department of Special Rehabilitation and Education, University of Novi Sad, Hajduk Veljkova 3, 21000 Novi Sad, Serbia
b Teachers' Training Faculty, Užice, University of Kragujevac, Serbia
c Clinic of Psychiatry, Faculty of Medicine, University of Novi Sad, Hajduk Veljkova 9, 21000 Novi Sad, Serbia
d Faculty of Special Education and Rehabilitation, University of Belgrade, Visokog Stevana 2, 11000 Beograd, Serbia

ABSTRACT

This paper presents the results of the study which examined the effects of carefully designed physical exercise programs on the development of physical fitness in children with ID. The study sample consisted of 42 children with ID and 45 typically developing children. All the participants were assessed using Eurofit Test Battery. The results were analyzed in terms of participation in the exercise program and level of intellectual functioning. While ID children scored significantly lower on fitness tests when compared with typically developing children, the study revealed an association between degree of ID and physical fitness.

1. Introduction

Children with intellectual disabilities (ID) exhibit numerous impairments in different domains of functioning. Alongside impairments in cognitive, social and adaptive behaviour, they also report lower levels of physical fitness at all stages of life (Pitetti & Boneh, 1995; Skowronski, Horvat, Nocera, Roswal, & Croce, 2009; Van De Vliet et al., 2006). Furthermore, numerous researchers have reported lower performance on standard fitness tests for the assessment of strength, endurance, flexibility and motor coordination, cardiovascular endurance in persons with ID (Chaiwanichsiri, Sanguanrungsirikul, & Suwannakul, 2000; Fernhall & Pitetti, 2001; Graham & Reid, 2000; Guideti, Franciosi, Gallota, Emeranziani, & Baldari, 2010; Horvat, Pitetti, & Croce, 1997; MacDonncha, Watson, McSweeney, & O'Donovan, 1999; Skowronski et al., 2009). Lower scores in the domain of physical fitness are associated with limited mental ability and short attention span (Vuijk, Hartman, Scherder, & Visscher, 2010), limitations and impediment in motor development (Frey & Chow, 2006; Hartman, Houwen, Scherder, & Visscher, 2010; Vuijk et al., 2010; Westendorp, Houwen, Hartman, & Visscher, 2011), sedentary lifestyle (Bickum, 1995; Lotan, Isakov, Kessel, & Merrick, 2004; Pitetti & Boneh, 1995), and lack of motivation to try one's best during testing (Halle, Gabler-Halle, & Chung, 1999). Test scores are influenced by gender, age, and level of intellectual disability (Fernhall & Pitetti, 2001; Skowronski et al., 2009). In that respect, children with mild ID have lower scores on locomotor skills than children with borderline ID (Hartman et al., 2010) and athletes with lower ID obtain higher performance scores in motor coordination test (Guideti et al., 2010).

Little information is available on the provision of physical fitness and intervention programs among people with intellectual disabilities, particularly concerning children with ID. Authors Hayakawa and Kobayashi (2011) reported significant improvement in children with ID in the 50m dash, mean 10m walk time, 10m obstacle course walk and a significant increase in the hip joint split angle. Earlier studies done on adults with ID reported beneficial effects of exercise as shown in statistical decreases in individual weight, especially among the mild disability level group, BMI score, and positive improvement in V-shape sit and reach test, sit-up tests. (Wu et al., 2010). Benefits of physical activity were observed in balance, strength, endurance and health self-perception (Carmeli, Zinger-Vaknin, Morad, & Merrick, 2005). Movement difficulties, impossible or impeded coordination of upper and lower limbs significantly reduce activities in children with ID, which is first observed in the family and school environment, and continues throughout adulthood. Reduced number of activities that would enable children to improve existing and develop new abilities may significantly affect their functioning in further everyday life, thereby putting them at risk of declining health associated with low physical fitness (Graham & Reid, 2000; Horvat & Croce, 1995; Piek, Dawson, Smith, & Gasson, 2008).

The aim of our research was to determine whether and to what extent application of different planned activities, i.e. specific exercise program, could affect the development of physical fitness in children with borderline and mild ID.

2. Method

2.1. Participants

The sample population consisted of 87 young school-age children, i.e. from 6.5 to 12 years old (mean 8, 6 SD 1, 89). Of the total number of participants, 42 were children with ID, enrolled in special schools, while 45 were children recruited from the general population, attending regular schools. All children were from a similar cultural background.

Of the 42 participants with ID, 23 were classified as having mild ID (52%) and 19 as having borderline ID (48%). The sample did not include children with Down Syndrome. The following criteria were observed when creating the sample of children with ID: presence of intellectual disability as defined by the American Psychiatric Association (2000); children in the 6.5–12 age range; normal neurological and health status. The study excluded children with metabolic diseases, as well as musculoskeletal, cardio and respiratory system diseases, in order to avoid potential influence of neurological and health factors on physical fitness test results. Accordingly, the sample did not include children with multiple disabilities. Furthermore, the sample did not include children who regularly participated in physical activities. The other group included typically developing children from local schools who were randomly selected and aligned according to gender and age with the group of children with ID. When creating this group the following criteria were observed absence of intellectual disability; children in the 6.5–12 age range; normal neurological and health status. The study excluded participants with metabolic diseases, as well as musculo-skeletal, cardio and respiratory system diseases, in order to avoid potential influence of neurological and health factors on physical fitness test scores. This group did not include children who participated in organized physical activities, either.

The first phase focused on creating the study groups with different treatment. Three treatment groups were formed. The first, experimental group (E) included 21 participants, 12 of whom were children with mild ID and 9 with borderline ID, all of whom participated in the fitness program.

The second group, control group 1 (K1), included the same number of participants (21), 11 of whom were diagnosed with mild ID, 10 with borderline ID. This group did not participate in the fitness program, but was only involved in the initial and final testing. In order to achieve adequate control of numerous other factors which may affect the scores, groups E and K1 were evenly matched and pairs were formed, whereby each child from group E was matched with a child of identical gender, age and IQ from group K1. Consequently, the two groups were aligned by gender, age and abilities. Children without disabilities made up the third group, control group 2 (K2), consisting of 45 typically developing participants, who did not participate in the fitness program, either.

The research was reviewed and approved by the Research Committee. Written consent was obtained from children's parents or guardians, as well as from schools administrators, who were informed about the aim and course of this research.

2.2. Procedure

Following the selection and alignment of the sample population, initial assessment of physical fitness was performed. Final assessment was done after the completion of the 6-month experimental program. Physical fitness was assessed in a sports facility that meet all the required criteria (health and sanitary requirements, adequately dimensioned space, lighting, adequate flooring, sufficient equipment and accessories, measuring instruments). After careful consideration of the initial results and assessment of all parameters related to the abilities of children with ID, individual programs were designed for all children from the experimental group. The 6-month fitness program consisted of 3 weekly sessions, each lasting 45 min, with activities performed with each child individually. The fitness sessions took place both during and outside school hours. The fitness program included a detailed description of exercises, exercise aim (e.g. developing coordination), time and venue (e.g. gym, Monday 14–14.45), person responsible for leading the program (e.g. name of the leader). Most of the activities were performed in the indoor sports facility and outdoor grounds, with participation of senior year students of the Teachers' Training Faculty, class teachers, as well as sports teachers. The activities performed were exercises recommended for development of specific physical fitness.

2.3. Materials

Physical fitness of children was evaluated applying the Eurofit Physical Fitness Test Battery (1993). The Eurofit Physical Fitness Test Battery is a set of nine physical fitness tests covering flexibility, speed, endurance and strength. The standardized test battery was devised by the Council of Europe. The test is designed so that it can be performed within 35–40 min, using very simple equipment. Research by Tsigilis, Douda, and Tokmakidis (2002) indicated high reliability of this battery in general population of children, whereas adequate reliability was confirmed when applied to mild ID or individuals without ID (MacDonncha, Watson, & McSweeney, 1999).

In this research five motor tests were used to monitor the following indicators of physical fitness: balance skills, strength and endurance. The following test descriptions were obtained from Eurofit Manual published online.

Assessment of static balance was performed using the Flamingo Balance Test. The task is to balance successfully on a single leg on a narrow-base beam 50 cm long, 4 cm high and 3 cm wide, coated with 5mm thick non-slip material. The number of successful attempts (without falls) to keep balance during 60 s is recorded.

Assessment of strength: (1) leg explosive strength was evaluated using the Standing Broad Jump Test. The task consists of performing a long jump using a two-foot take-off. The better of the two attempts is recorded. Results are expressed in cm. (2) Functional strength–strength of arms and shoulders was tested using the Bent Arm Hang Test. The task is to hold the hanging position with flexed arms on a horizontal bar 2.5–4 cm in diameter. The total time in seconds is recorded, with an accuracy of 1/10 s.

Assessment of endurance: (1) abdominal muscle endurance was assessed using the Sit-up Test. The task is to perform as many sit-ups as one can in 30 s, with one's knees at right angles and feet flat on the floor. The number of complete sit-ups performed within the stipulated period of time is recorded. A complete sit-up cycle encompasses period from lying on the floor, lifting the body into the sitting position and returning to the starting position. (2) Cardio-respiratory endurance was tested using the Multistage 20 m Shuttle Run Test. The task is to perform as many runs for a preset distance at a steady pace. Cardio-respiratory endurance test starts with walking, and ends with fast running. The test is over when the participant is no longer able to follow the rhythm, i.e. when the subject fails to reach the line before the beep sounds. The time spent in testing, expressed in seconds, is recorded.

2.4. Data analysis

Statistical analysis was performed using the SPSS 16.0 statistical software. Descriptive statistics were used to describe arithmetic mean (Mx My), standard deviation (SDx Sdy) and minimum and maximum values of scores on initial and final fitness assessments (Xmin, Xmax; Ymin, Ymax) for the basic features of the study, i.e. strength, balance skills and endurance.

Differences on initial and final assessment between experimental and control groups, as well as between mild and borderline ID were established using t-test. The level of statistical significance of differences related to fitness test performance and monitoring of effects of experimental factors was determined using analysis of variance (ANOVA). A significance level of $p \leq 0.05$ was considered statistically significant.

3. Results

Data analysis involved calculating mean values for initial and final fitness assessment, as well as adjusting the mean value that represented correlation between initial and final scores. Analysis of variance in all three treatment groups suggested that cross-group differences were greater than differences within individual groups ($p \leq 0.05$). The actual progress and its significance during the experimental program were assessed by examining the results of the multiple covariate analysis which allowed for longitudinal monitoring of the exercise effects. Test results are presented in Table 1.

Table 1

Mean values for initial and final assessment

	Group	N	Mx	SDx	My	SDy	Myp
Balance	E	21	27.905	3.129	21.095	4.323	16.581*
	K1	21	28.714	1.765	27.286	3.085	22.098
	K2	45	17.511	7.276	16.600	6.943	20.726
Strength Standing Broad Jump	E	21	100.762	32.614	118.429	24.384	139.979*
	K1	21	104.286	24.822	105.762	24.944	124.273
	K2	45	134.956	27.135	137.667	24.718	129.716
Strength Bent Arm Hang Test	E	21	11.148	8.551	24.720	10.192	33.303*
	K1	21	10.915	8.209	13.707	8.209	22.517
	K2	45	25.331	12.523	27.787	13.320	22.507
Endurance of abdominal muscles	E	21	3.905	4.711	13.190	4.131	19.561*
	K1	21	5.048	4.533	6.571	5.124	11.980
	K2	45	14.667	7.943	16.533	7.335	13.846
Cardio-respiratory endurance	E	21	71.286	22.799	140.095	38.443	177.504*
	K1	21	72.476	23.773	83.952	24.646	120.156
	K2	45	149.978	58.455	168.844	61.371	126.603

N – number of participants

Mx - mean value on initial assessment

SDx – standard deviation on initial assessment

My - mean value on final assessment

Sdy - standard deviation on final assessment

Myp – adjusted mean value

E-children with ID involved in exercise

K1- children with ID not involved in exercise

K2-typically developed children not involved in exercise

*group that showed best improvement

Data analysis revealed significantly lower performance on initial fitness assessment in the groups of children with intellectual disability (both E and K groups) when compared with the typically developing children. Consequently, children with ID made the greatest number of attempts to keep balance, performed shortest length of the jump and demonstrated poorest endurance capacity during workout while keeping the workout intensity unchanged. No statistically significant difference was observed between initial and final assessments within groups; however, calculated adjusted mean value representing longitudinal monitoring of the effect of experimental factor (Myp) indicated best improvement in children from the experimental group (E) involved in the exercise and planned physical activity program ($p \leq 0.05$). Descriptive indicators suggested that best final fitness assessment scores were observed in children without disability; however, best improvement of physical ability resulting from the experimental exercise program was accomplished in the experimental group (E).

Further analysis established effects of carefully designed exercises and physical activity program in children with mild ID and borderline ID, which are displayed in Table 2.

Table 2

Mean values of tests on initial and final assessment in children with mild ID and borderline ID

	Group	N	Mx	SDx	My	SDy	Myp
Balance	E –Mild ID	12	29.333	1.497	22.667	3.367	16.931
	E-Borderline ID	9	26.000	3.775	19.000	4.743	16.052*
	K–Mild ID	11	28.636	2.063	27.091	3.448	21.938
	K-Borderline ID	10	28.800	1.476	27.500	2.799	22.211
Strength Standing Broad Jump	E –Mild ID	12	96.250	33.265	116.083	22.797	141.392*
	E-Borderline ID	9	106.778	32.656	121.556	27.432	137.830
	K–Mild ID	11	109.909	28.529	112.273	28.513	125.859
	K-Borderline ID	10	98.100	19.587	122.321	19.248	122.321
Strength Bent Arm Hang Test	E –Mild ID	12	9.817	8.046	23.008	9.830	33.048
	E-Borderline ID	9	12.922	9.359	27.002	10.797	33.959*
	K–Mild ID	11	12.308	9.644	13.684	9.617	21.250
	K-Borderline ID	10	9.383	6.435	13.732	6.856	24.202
Endurance of abdominal muscles	E –Mild ID	12	1.917	3.088	11.583	3.343	19.570*
	E-Borderline ID	9	6.556	5.341	15.333	4.272	19.444
	K–Mild ID	11	5.091	4.549	6.455	5.087	11.789
	K-Borderline ID	10	5.000	4.761	6.700	5.438	12.110
Cardio-respiratory endurance	E –Mild ID	12	71.500	23.903	135.083	34.917	172.112
	E-Borderline ID	9	71.000	22.666	146.778	43.937	184.311*
	K–Mild ID	11	65.430	21.034	72.870	21.453	90.563
	K-Borderline ID	10	73.400	20.065	89.000	20.765	100.343

Mx - mean value on initial assessment

SDx – standard deviation on initial assessment

My - mean value on final assessment

Sdy - standard deviation on final assessment

Myp – adjusted mean value

*group that showed best improvement

The mean values indicated that children with mild ID scored lower on initial fitness assessment when compared to children with borderline ID. On final assessment, the results were improved in all three groups; however, adjusted mean values (Myp) indicated best improvement of balance, bent arm hanging test and cardio respiratory endurance in children with borderline ID from group E. Children with mild ID from the same group showed better strength improvement by long jump and abdominal muscle endurance. Children with ID from the control group (K1) who did not participate in exercise, demonstrated improvement on final assessment, which was probably due to learning and acquaintance with testing situation; their improvement, however, remained poorer when compared with children who were involved in the exercise program.

Comparison of improvement differences between groups revealed statistical significance between groups E and K1 and K2 (Table 3), but evaluation of improvement of mild and borderline ID children within the experimental group E did not indicate any statistically significant differences (Table 4).

Table 3

T-test results between groups

	Group	dMy'	SEd	t	p
Balance	E and K1	5.518	0.859	6.421	0.000
	E and K2	4.145	0.736	5.633	0.000
Strength Standing Broad Jump	E and K1	15.707	1.869	8.405	0.000
	E and K2	10.263	1.600	6.413	0.000
Strength Bent Arm Hang Test	E and K1	10.786	1.748	6.172	0.000
	E and K2	10.796	1.497	7.214	0.000
Endurance of abdominal muscles	E and K1	7.581	0.889	8.525	0.000
	E and K2	5.715	0.762	7.504	0.000
Cardio-respiratory endurance	E and K1	57.348	7.310	7.845	0.000
	E and K2	50.901	6.260	8.131	0.000

E-children with ID involved in exercise

K1- children with ID not involved in exercise

K2-typically developed children not involved in exercise

dMy'- difference between two adjusted arithmetic means

SEd- standard error of difference between two adjusted arithmetic means

Table 4

T-test results according to the level of intellectual functioning

	Group	dMy'	SEd	t	p
Balance	E –Mild ID/E-Borderline ID	0.880	1.221	0.720	0.307
Strength- Standing Broad Jump	E –Mild ID/E-Borderline ID	3.563	2.556	1.394	0.151
Strength - Bent Arm Hang Test	E –Mild ID/E-Borderline ID	0.911	2.335	0.390	0.369
Endurance of abdominal muscles	E –Mild ID/E-Borderline ID	0.127	1.255	0.101	0.396
Cardio-respiratory endurance	E –Mild ID/E-Borderline ID	12.198	10.321	1.182	0.198

dMy'- difference between two adjusted arithmetic means

SEd- standard error of difference between two adjusted arithmetic means

4. Discussion

We examined the effects of carefully designed physical exercise programs on the physical fitness in children with ID and compared the results obtained before and after participation in a specially designed program. Results were monitored according to the level of intellectual functioning of the group of children involved in the exercise program compared to the two groups of children who did not exercise. Physical fitness of ID children was significantly lower when compared with those of age- and gender-matched typically developing children, based on results of all the motor tests. These results are consistent with previous reports of Bala (1983), Nikolić and Ilić (2007), Hartman et al. (2010) and Westendorp et al. (2011). Poor performance was manifested particularly on the item that tested the ability to keep balance, which was most probably associated with the child's inability to react adequately to visual and proprioceptive information. Reduced primary potential prevents children with ID from receiving adequate important information, thus disabling appropriate balance maintenance good posture (Hale, Bray, & Littmann, 2007; Minshew, Sung, Jones, & Furman, 2004). Back muscle weakness and spinal deformities, frequently occurring in children with ID, can affect endurance capacity of abdominal muscles resulting in the child's poor exercise performance. Such low scores on all the assessed components can be attributed to the tendency among ID children to be less active and lead a more sedentary lifestyle, and to the lack of sufficient stimuli for complete development as well as physical activities necessary for achieving flexibility, resilience, balance and endurance (Bickum, 1995; Graham & Reid, 2000; Lotan et al., 2004; Pitetti & Boneh, 1995).

Performance of children on the fitness tests was compared according to the level of their intellectual functioning. Even though no statistically significant difference was found when comparing outcomes in the group involved in physical exercise with respect to intellectual functioning of children, there was still apparent difference with respect to exercise type, i.e. abilities and skills that were improved in such children. Hence, children with borderline ID demonstrated better improvement in balance keeping (the differences in the scores can be related to the type and level of ID) (Franciosi, Baldari, Gallotta, Emerenciani, & Guidetti, 2010), flexed arm hang test and cardio respiratory endurance, whereas children with mild ID showed better performance in the strength test (long jump) and abdominal muscle endurance test. Surprisingly, children which is not characteristic for this child population. This could be attributed to the sample population itself, and may not be used to make generalizations that could apply to the entire population of children with ID. Better scores of children with borderline ID on particular tests can be attributed to the very nature of the exercise, as well as to their superior abilities compared to the children with mild ID. Although strength and endurance did not prove characteristic for children in other research (Bala & Popović, 2007; Van De Vliet et al., 2006), our research suggested that these abilities were highly improvable in children with ID.

Difference in physical fitness was established between children who were involved in physical exercise program and children who did not exercise. Children who participated in specially designed physical activity program scored better on final assessment than children from control group 1 (K1), who did not exercise. Final fitness assessment revealed improved outcomes on all tests for children with ID who participated in the exercise program. Although the results were still poorer than those of typically developing children who were not involved in exercise, longitudinal monitoring demonstrated improvement in the development of tested abilities.Wecould say that a program of planned physical exercise contributed to development of abilities enabling successful performance of motor tasks, above all strength, coordination of upper and lower limbs, movement control, equalization and regulation of muscle tone and spatial orientation.

Our study revealed that children with ID, though involved in the exercise program, did not reach the level of physical fitness of typically developing children. These data are consistent with research findings of Bala and Popović (2007) and Westendorp et al. (2011) indicating, however, the important role of physical fitness in the development of such skills.

Results of our experimental program support the idea that properly selected exercises can improve the development of particular skills in children with intellectual disability. Limitations of this study pertain to the small sample size, as well as difficulties in controlling all factors that could affect the exercise process itself, such as motivation, interest in taking part in the program, health status. Furthermore, study results could not explain why there were no differences in improvement among children who exercised, related to their intellectual functioning. In that respect, further longitudinal monitoring is required to establish possible association of those factors.

5. Conclusion

Children with ID scored significantly lower on all physical fitness tests than typically developing children. These abilities were associated with decreased level of intellectual functioning, thus children with borderline ID scored better on balance and endurance than children with mild ID. It was found that improvement of physical fitness was closely related to physical exercise. Results of this research indicated that carefully designed and targeted physical activity program could significantly influence development of physical fitness in children with ID. The research emphasized the importance of carefully tailoring the exercise programs to the needs and abilities of each individual child with the aim of developing and improving his or her physical fitness.

Conflict of interest statement

The authors declare that they have no competing interest.

References

American Psychiatric Association (2000). Diagnostic and statistical manual of mental disorder (4th ed.) Text revised. Washington, DC.

Bala, G. (1983). Relacije antropometrijskih karakteristika imotoričkih sposobnosti lakše psihički ometenih učenika i učenika redovnih škola. *Defektologija*, *1*, 31–38.

Bala, G., & Popović, B. (2007). Motoričke sposobnosti predškolske dece. U: Antropološke karakteristike i sposobnosti predškolske dece (Urednik G. Bala). Novi Sad: Fakultet sporta i fizičkog vaspitanja. pp. 101–150.

Bickum, D. (1995). The history of graded exercise testing in cardiac rehabilitation. Oregon: Microform Publication.

Carmeli, E., Zinger-Vaknin, T., Morad, M., & Merrick, J. (2005). Can physical training have an effect on well-being in adults with mild intellectual disability? *Mechanisms of Ageing and Development*, *126*(2), 299–304.

Chaiwanichsiri, D., Sanguanrungsirikul, S., & Suwannakul, W. (2000). Poor physical fitness of adolescents with mental retardation at Rajanukul School, Bangkok. *Journal of the Medical Association of Thailand*, *83*, 1387–1392.

Eurofit Physical Fitness Test Battery (1993). Eurofit tests of physical fitness (2nd ed.) Strasbourg. Eurofit Manual Retrieved from http://www.topendsports.com/testing/eurofit.htm.

Fernhall, B., & Pitetti, K. H. (2001). Limitations to physical work capacity in individuals with mental retardation. *Clinical Exercise Physiologist*, *3*, 176–185.

Franciosi, E., Baldari, C., Gallotta, M. C., Emerenciani, G. P., & Guidetti, L. (2010). Selected factors correlated to athletic performance in adults with mental retardation. *Journal of Strength and Conditioning Research*, *24*(4), 1059–1064.

Frey, G. C., & Chow, B. (2006). Relationship between BMI, physical fitness, and motor skills in youth with mild intellectual disabilities. *International Journal of Obesity*, *30*, 861–867.

Graham, A., & Reid, G. (2000). Physical fitness of adults with an intellectual disability: A 13-year follow-up study. *Research Quarterly for Exercise and Sport*, *71*(2), 152–161.

Guideti, L., Franciosi, E., Gallota, M. C., Emeranziani, G. P., & Baldari, C. (2010). Could sport specialization influence fitness and health of adults with mental retardation? *Research in Developmental Disabilities*, *5*, 1070–1075.

Hale, L., Bray, A., & Littmann, A. (2007). Assessing the balance capabilities of people with profound intellectual disabilities who have experienced a fall. *Journal of Intellectual Disability Research*, *51*(4), 260–268.

Halle, J. W., Gabler-Halle, D., & Chung, Y. B. (1999). Effects of a peer mediated aerobic conditioning program on fitness levels of youth with mental retardation: Two systematic replications. *Mental Retardation*, *37*, 435–448.

Hartman, E., Houwen, S., Scherder, E., & Visscher, C. (2010). On the relationship between motor performance and executive functioning in children with intellectual disabilities. *Journal of Intellectual Disability Research*, *54*, 468–477.

Hayakawa, K., & Kobayashi, K. (2011). Physical and motor skill training for children with intellectual disabilities. *Perceptual and Motor Skills*, *112*(2), 573–580.

Horvat, M., & Croce, R. (1995). Physical rehabilitation of individuals with mental retardation; physical fitness and information processing. *Critical Reviews in Physical and Rehabilitation Medicine*, *7*, 233–252.

Horvat, M., Pitetti, K. H., & Croce, R. (1997). Isokinetic torque, average power, and flexion/extension ratios in nondisabled adults and adults with mental retardation. *Journal of Orthopaedic and Sports Physical Therapy*, *25*(6), 395–399 Retrieved from www.scopus.com.

Lotan, M., Isakov, E., Kessel, S., & Merrick, J. (2004). Physical fitness and functional ability of children with intellectual disability: Effects of a short-term daily treadmill intervention. *The Scientific World Journal*, *4*, 449–457.

MacDonncha, C., Watson, A. W. S., McSweeney, T., & O'Donovan, D. J. (1999). Reliability of Eurofit physical fitness items for adolescent males with and without mental retardation. *Adapted Physical Activity Quarterly*, *16*(1), 86–95.

Minshew, N. J., Sung, K., Jones, B. L., & Furman, J. M. (2004). Underdevelopment of the postural control system in autism. *Neurology*, *63*, 2056–2061.

Nikolić , S., & Ilić , S. (2007). Motoričke sposobnosti dece razvojnih grupa. Naučni skup Nove tendencije u specijalnoj edukaciji i rehabilitaciji. Beograd, 605–614.

Piek, J. P., Dawson, L., Smith, L. M., & Gasson, N. (2008). The role of early fine and gross motor development on later motor and cognitive ability. *Human Movement Science*, *27*(5), 668–681.

Pitetti, K. H., & Boneh, S. (1995). Cardiovascular fitness as related to leg strength in adults with mental retardation. *Medicine and Science in Sports and Exercise*, *27*(3), 423–428 Retrieved from www.scopus.com.
Skowronski, W., Horvat, M., Nocera, J., Roswal, G., & Croce, R. (2009). Eurofit special: European fitness battery score variation among individuals with intellectual disabilities. *Adapted Physical Activity Quarterly*, *26*(1), 54–67 Retrieved from www.scopus.com.
Tsigilis, N., Douda, H., & Tokmakidis, S. P. (2002). Test–retest reliability of the Eurofit test battery administered to university students. *Perceptual and Motor Skills*, *95*, 1295–1300.
Van De Vliet, P., Rintala, P., Fro¨ jd, K., Verellen, J., Van Houtte, S., Daly, D. J., et al. (2006). Physical fitness profile of elite athletes with intellectual disability. *Scandinavian Journal of Medicine and Science in Sports*, *16*(6), 417–425 Retrieved from www.scopus.com.
Vuijk, P. J., Hartman, E., Scherder, E., & Visscher, C. (2010). Motor performance of children with mild intellectual disability and borderline intellectual functioning. *Journal of Intellectual Disability Research*, *54*, 955–965.
Westendorp, M., Houwen, S., Hartman, E., & Visscher, C. (2011). Are gross motor skills and sports participation related in children with intellectual disabilities? *Research in Developmental Disabilities*, *32*, 1147–1153.
Wu, C. L., Lin, J. D., Hu, J., Yen, C. F., Yen, C. T., Chou, Y. L., et al. (2010). The effectiveness of healthy physical fitness programs on people with intellectual disabilities living in a disability institution: Six-month short-term effect. *Research in Developmental Disabilities*, *31*, 713–717.