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ORIGINAL SCIENTIFIC PAPER

Circuit Training Intervention for Adaptive Physical Activity to Improve Cardiorespiratory Fitness, Leg Muscle Strength Static and Balance of Intellectually Disabled Children

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Abstract

Physical activity intervention programmes have been found to effectively improve cardiorespiratory fitness, strength, and balance. However, few studies thus far have examined the effects of a circuit training physical activity adaptive programmed to improve the cardiorespiratory fitness, leg muscle strength and balance of the static environment of children with intellectual disabilities. The purpose of this study was to examine the effects of the adaptive activity circuit training of six weeks performed three times per week on the cardiorespiratory fitness (VO2 max), leg muscle strength, and balance of intellectually disabled children. The research method was experimental with group pretest-posttest design. The subject of this study was 15 male students with mild intellectual disabilities aged from 15 to 17 years who followed sport extracurricular activities taken by random sampling. The cardiorespiratory fitness (VO2 max) measurement used the modified Queen's College Step Test; leg muscle strength was measured using a leg dynamometer; static balance was measured using a stork stand test. The data were analysed with a paired samples test using SPSS. The results showed significantly increased ($p<0.05$) cardiorespiratory fitness, leg muscle strength, and static balance at the end of the intervention period of the circuit training physical activity adaptive programme. It has been concluded that the circuit training physical activity adaptive programme of six weeks, at a frequency of three times per week was effective for improving cardiorespiratory fitness (VO2 max), leg muscle, strength and balance.

Key words: *circuit training, cardiorespiratory, leg muscle strength, balance, intellectual disabilities*

Introduction

Physical activity programmes (PA) are adapted as necessary for children with intellectual disabilities to improve their cardiorespiratory ability, endurance, strength and balance (Boswell, 1993; Fotiadou, Neofotistou, Sidiropoulou, Tsimaras, Mandroukas, & Angelopoulou, 2009; Giagazoglou, Arabatzi, Dipla, League, & Kellis, 2012; Giagazoglou et al., 2013; Jankowicz, Mikolajczyk, & Wojtanowski, 2012; Tsimaras, Giamouridou, Kokaridas, Sidiropoulou, & Patsiaouras, 2012). Cardiorespiratory ability (VO2 max) is the basic component of a person's fitness complex, because it involves the function of the heart, lungs, and the ability of blood vessels and capillaries to send oxygen to all parts of

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the body to create energy. The balance of fitness components is essential to maintain the head and body against gravity and the force from outside and maintain the body's centre of mass to the plane of the pivot. Physical activity programmes adapted to develop cardiorespiratory fitness and balance for children with intellectual disabilities are essential for the wellbeing of children.

Based on the results of a study, the general condition of cardiorespiratory fitness and muscular strength of children with intellectual disabilities (ID) is very low compared with those without intellectual disabilities (Temple, Frey, & Stanish, 2006; Pitetti, Yarmer, & Fernhall, 2001; Pitetti & Yarmer, 2002; Gillespie, 2003; Lotan, Isakov, Kessel, & Merrick, 2004; Dixon, Lee, & Dugala, 2013). The lower levels of cardiorespiratory fitness and muscular strength of children with intellectual disabilities than those without intellectual disabilities are a result of the fact that they do less physical activity and have less motivation to do physical activity (Pitetti, Beets, & Combs, 2009). Children with intellectual disabilities have inactive lifestyles or fewer opportunities for physical exercise, and they have high health risks (Ayvazoglu, Ratliffe, & Kozub, 2004).

In addition, children with mild intellectual disabilities (MID) often have limited motor skills (Westendorp, Houwen, Hartman, & Visscher, 2011). Delays and limitations of the development of motor skills are due to the condition of the brain, which affects its cognitive and motor function (Giagazoglou et al., 2012). The research of Guidetti, Franciosi, Gallotta, Emerenziani, and Baldari (2010) showed that children with intellectual disabilities faced difficulty in coordinating movement from childhood to adulthood. Such difficulties resulted in the lower performance on tests of balance (Hale, Bray, & Littmann, 2007; Minshew, Sung, Jones, & Furman, 2004).

The results of the above studies demonstrated that children with intellectual disabilities had limitations and difficulties of coordination and balance, and the level of physical fitness included cardiorespiratory ability, muscle strength, and muscle endurance were low compared to children without intellectual disabilities. How can exercise intervention be guided in order to improve the balance and physical fitness of children with intellectual disabilities? Few studies have been conducted on this topic. Specifically, most of the studies related to the use of design implementation effectiveness of a cross-sectional survey with a questionnaire to assess physical activity behaviour. This has limitations regarding exercise participation; in particular, changes cannot be observed, and only a simple relationship can be inferred. The lack of adaptive activity programmes that can be applied in school and on the training field is a limiting factor to develop the physical fitness of children with special needs.

Based on the statement above, the purpose of this study was to test the intervention programme of an adaptive circuit workout that can improve cardiorespiratory fitness, leg muscle strength and static balance among children with intellectual disabilities.

Methods

Participants

The participants of this study were 15 male students with mild intellectual disabilities aged 15 to 17 years who participated in extracurricular sports.

Research procedure

The research was carried out in two stages. The first stage was a literature review of previous research to develop an intervention programme of an adaptive circuit training for children with intellectual disabilities. The content validity was reviewed and tested by three physical education specialists. The second stage of the experiment had a one-group pretest-posttest design. Participants were given training (treatment) exercise three times per week for six weeks. Before and after treatment, participants' cardiorespiratory endurance, coordination, and static balance were tested.

Intervention

The adaptive circuit programme was developed and designed based on the literature and the results of previous research. Once developed, it was validated by three experts to assess the Delphi technique. The results of the assessment data validation of three experts were calculated using the formula content validity ratio (CVR) to obtain an agreement. The more the data approach CVR=1 the better the data are. The circuit training programme composed by six stations with 5 meter spacing was used to evaluate the cardiorespiratory, strength and balance of children intellectual disabilities. The programme was composed by the following stations: Station 1: shuttle run 6 beams move a distance of 5 meters, Station 2 sit-ups 10 times, Station 3 corks jump 10 centimeters 8 times, Station 4 BAKS up 10 times, Station 5 push-ups 10 times, Station 6 runs above the beam (width of 12 centimeters and a length of 4 meters). Circuit training is carried out for six weeks with a frequency of three times per week. From first and second week the circuit training program has been done twice for each week. The resting time was 3 minutes between the repetitions, and on the third and fourth weeks there was an increasing of volume and intensity; the circuit training program has been done 3 times per week with the same time of resting 3 minutes after one circuit. On the two last weeks (the fifth and sixth), the circuit training program still occurred 3 times per week but only there was a restriction of resting time (now 2 minutes)

Measurements

The data were obtained first by pre-test of the following variables: (1) cardiorespiratory fitness (VO2max), (2) leg muscle strength, and (3) static balance. The pre-test was done to establish the strengths and weaknesses of the athlete or someone else. After the training during 6 weeks, the post-test of the previous variables has been conducted because the fitness testing is a great way to monitor and assess athlete' ability as it relates to aerobic fitness, strength, and static balance. It can also help the athlete or someone else to understand how healthy they are and learn to set goals to improve their health-related fitness.

Cardiorespiratory fitness (VO2 max)

Cardiorespiratory fitness can be determined by the value of the volume of maximum oxygen uptake (VO2max) (Foster, 1983). Cardiorespiratory Fitness value (VO2 max) max The VO2 max has been tested by using the Queen's College Step Test is modified. The necessary tools are blocks (28 cm high), a stopwatch, and a metronome. Study participants do step movement up and down the block as high as 28 cm by 22 times up and down the stairs per minute (88 steps per minute) for 3 minutes without break. After 3 minutes, participants were asked to sit down, and their pulse rate was calculated using the radial artery for 1 minute. Counts were recorded as a heart rate of their recovery.

Leg muscle strength

Leg muscle strength in this study was measured using the leg dynamometer (CYBEX division of Lumex). Implementation: the subject wears a waist fastener, then stood with his knees bent up to an angle of ± 45º, then the tool is attached to a waist fastener. After that, the subjects do their utmost with both legs. After the test, it has been seen that the legs were strengthened to the maximum, and then the needle of the device showed the number. The figure states the level of leg muscle strength. Rating: the best score of the three trials is recorded as the score in units kg, with a level of accuracy of 0.5 kg (Barry & Jack, 1979).

Static balance

Static balance is the ability to control the balance in the treatment of standing, sitting, and relative stillness. Static balance is measured using the Stork Stand Test. Participants using the pedestal stand with one leg that is considered stronger. One foot is positioned and bent beside the foot of the pedestal. Hand holding the waist, with eyes closed and the researchers commanded the movement by to counting: 1, 2, and 3 (one, two, and three). Participants must maintain the position. Scores are expressed in seconds.

Results

Test of normality of each variable

According to Table 1, the test normality using Kolmogorov-Smirnov obtained the significance value of each variable: the variable pretest had a significance value of 0.951; cardiorespiratory fitness and cardiorespiratory fitness posttest had a significance value of 0.961; strength pretest variables muscles had a significance value of 0.740, and posttest leg muscle strength has a significant value of 0.309; balance variable significant value 0.799 for the pretest. and posttest balance the significant value was 0.797. All of these variables were significantly greater than 0.05; therefore, it can be concluded that all the variables were normally distributed.

Table 1. Kolmogorov-Smirnov Test Results (N=15)

Test	Pre-test Cardio	Post-test Cardio	Pre-test Power	Post-test Power	Pre-test balance	Post-test balance
Normal Parameters[a, b]	35.036	37.9	81.333	94.6	6.00	7.7333
Sig. (2-tailed)	.951	.961	.740	.309	.799	.797

Different Test Results pretest and posttest Cardiorespiratory fitness.

Paired samples based on the analysis of different test cardiorespiratory fitness pretest and posttest results are as follows:

Table 2. Paired Samples Test (N=15)

	Pre-test Cardio	Post-test Cardio	Sig. (2-tailed)
Mean	35.0360	37.9253	-
Pretest-Posttest Cardiorespiratory	35 ml/kg/min	45 ml/kg/min	.000

Different Test Results pretest and posttest Leg Muscle Strength

Based on the analysis of different paired samples, pretest and posttest muscle leg strength result, as in Table 3, showed:

Table 3. Paired Samples Statistics of Strength (N=15)

Test	Pre-test Strength	Post-test Strength	Sig. (2-tailed)
Mean	81.3333	94.6667	.000

Based on Table 3, the results showed the value of significance (2-tailed) was 0.00 ($p<0.05$). Nevertheless, with a statistical analysis of paired samples, the descriptive value of final test leg muscle strength average 94.6667 is higher than the average value of the initial test of 81.3333. Therefore, we concluded that the circuit exercise training programme increased leg muscle strength in children with intellectual disabilities.

Different Test Results pretest and posttest Balance

The Table 4 below showed different test Paired Samples, pre-test and post-test balance of the subject tested.:

Table 4. Paired Samples Statistics of Balance (N=15)

Test	Pre-test Strength	Post-test Strength	Sig. (2-tailed)
Mean	6.0000	7.7333	.000

Table 4 showed the value of significance (2-tailed) was 0.00 ($p<0.05$). Therefore, the results of initial test and final test had significant changes. In the same table, we saw that the statistical analysis of paired samples descriptive value of the final test of static balance was on average 7.733 higher than the average value of initial tests 6.000. Therefore, we concluded that the circuit exercise training programme improved the static balance child with intellectual disabilities.

Discussion

The results showed that participants with mild intellectual disabilities after training have significantly increased cardiorespiratory fitness (VO2 max; $p<0.05$). Furthermore, it was shown that the final descriptive test value of VO2 max 37.925 millilitres/kilogram body weight/minute (ml/kg/minute) higher than the initial VO2 max test average of 35.036 ml/kg/minute. The findings of this study are reinforced by several research results (Alcaraz & Blazevich, 2008; Giannaki, Aphamis, Tsouloupas, Ioannou, & Hadjicharalambous, 2016; S. Romero, Martinez, & Alcaraz, 2013; Mayorga-Vega, Viciana, & Cocca, 2013) that stated that circuit programs with resistance and carried out repeatedly within six weeks to eight weeks could increase cardiorespiratory ability. In addition, the results of the studies of Mayorga el al. (2013), and Schmidt, Anderson, Graff, and Strutz (2016) state that physical activity programmes using circuit training can increase endurance cardiorespiratory strength.

This study also found that there was a significant increasing of leg muscle strength ($p<0.05$) for children with intellectual disabilities after conducting the circuit training programme. It was also shown that there was an increasing of average yield of leg muscle strength pretest (mean 81.33) to the leg muscle strength in posttest with (mean 94.66). The findings of this study were similar to the results of several studies that stated that circuit training programs can increase muscle strength (Wirat, Pratoom, & Sootmongkol, 2017; Mayorga et al., 2013; Schmidt et al., 2016; Giannaki et al., 2016)

It was also shown that there was an increasing in the results of static balance pretest (mean 6.00) and posttest of static balance test (mean 7.70). The findings of this study were similar to those of Jankowicz et al. (2012) and Giagazoglou et al. (2013), which stated that circuit training improved static and dynamic balance.

Circuit training programmes can improve cardiorespiratory fitness, leg muscle strength, and the balance of children with intellectual disabilities, when the children were enthusiastic and motivated in carrying out the exercises. This was similar to the results of research by Jan Wilke (2018) stating that circuit training with low intensity can increase the motivation of practicing children.

Based on the research results and the above discussion, it can be concluded that the circuit adaptive activity programme can improve cardiorespiratory fitness, leg muscle strength, and static balance for the child mild intellectual disabilities. The programme can be used by physical education teachers in schools to improve cardiorespiratory fitness, leg muscle strength, and balance for children with intellectual disabilities.

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Conflict of Interest
The authors declare that there are no conflicts of interest.

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References

Ayvazoglu, N.R., Ratliffe, T., Kozub, F.M. (2004). Encouraging lifetime of physical fitness. *Teaching Exceptional Children, 37*(2), 16-20.

Barry, L.J., & Jack, K.N. (1979). *Practical measurements for evaluation in physical education* /. -3d ed. 1- 470, Minneapolis: Burgess Pub. Co., c1979.

Boswell, B. (1993). Effects of movement and creative dance sequences on balance of children with mental retardation. *Percept Mot Skills, 77*, 1290.

Giannaki, C.D., Aphamis, G., Tsouloupas, C.N., Ioannou, Y., & Hadjicharalambous, M. (2016). An eight week school-based intervention with circuit training improves physical fitness and Reduces body fat in male adolescents. *The Journal of Sports Medicine and Physical Fitness , 56*(6-8), 894-900.

Daniel, M.V., Viciana, J., & Armando, C. (2013). Effects of a Circuit Training Program on Muscular and Cardiovascular Endurance and their maintenance in choolchildren. *Journal of Human Kinetics, 37*, 153-160.

Schmidt, D., Anderson, K,. Graff, M., & Strutz, V. (2016). The effect of high-ntensity circuit training on physical fitness. *The Journal of Sports Medicine and Physical Fitness, 56*(5), 534-540.

Dixon, I.A., Lee, M, & Dugala, A. (2013). Physical activity and sedentary behavior in older adults with intellectual disabilities: a comparative study. *Adapt Activ Q. Phys, 30*, 1-19

Foster, C. (1983). VO2 max and training indices as determinants of competitive running performance. *Journal of Sports Sciences, 1*(1), 13–22. doi:10.1080/02640418308729657

Fotiadou, E.G., Neofotistou, K.H., Sidiropoulou, M.P., Tsimaras, V.K., Mandroukas, A.K., & Angelopoulou, N.A. (2009). The effect of a rhythmic gymnastics program on the dynamic balance of individualswith intellectual abilities disability. *J Strength Cond Res., 23*, 2102-2106.

Gillespie, M. (2003). Cardiovascular fitness of young Canadian children with and without mental retardation. *Education and Training in Developmental Disabilities, 38*, 296-301.

Guidetti, L., Franciosi, E., Gallotta, M., Emerenziani, G., & Baldari, C. (2010). Could Influence Specialization Sport Fitness and Health of Adults with Mental Retardation? *Research in Developmental Disabilities, 31*, 1070-1075. https://doi.org/10.1016/j.ridd.2010.04.002

Giagazoglou, P., Arabatzi, F., Dipla, K., League, M., & 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.

Giagazoglou, P., Kokaridas, D., Sidiropoulou, M., Patsiaouras, A., Karra, X., & Neofotistou, K. (2013). Effects of a trampoline exercise intervention on the motor performance and balance abilities of children with intellectual disabilities. *Dev Disabil Res, 34*, 2701-2707.

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*, 260-268. https://doi.org/10.1111/j.1365-2788.2006.00873.x

Jankowicz, A., Mikolajczyk, E., & Wojtanowski, W. (2012) Theeffect of physical training on static balance in young people with intellectual disability. *Dev Disabil Res, 33*, 675-681.

January ,W., Stefanie Kaiser, K., Daniel, N., Kristin, K., Tobias, E., Christian, M.V., & Winfried, B. (2018). Effects of high-functional circuit training intensity on the motor function and motivation in sport healthy, inactive adults. *Scandinavian Journal of Medicine & Science in Sports, 29*(1) 144 159. https://doi.org/10.1111/sms.13313

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

Minshew, N.J., Sung, K., Jones, B.L., & Furman, J.M. (2004). Underdevelopment of the Postural Control System in Autism. *Neurology, 63*, 2056-2061. https://doi.org/10.1212/01.WNL.0000145771.98657.62

Pitetti, K.H., Yarmer, D.A., & Fernhall, B. (2001). Cardiovascular fitness and body composition of youth with and without mental retardation. *Adapted Physical Activity Quarterly, 18*, 127-141.

Pitetti, K.H., & Yarmer, D.A. (2002) Lower body strength of children and adolescents with and without mental retardation: A comparison. *Adapted Physical Activity Quarterly, 19*, 68-81.

Pitetti, K.H., Beets, M.W., & Combs, C. (2009). Physical activity levels of children with intellectual disabilities during school. *Medicine and Science in Sports and Exercise, 41*(8), 1580-1586.

Alcaraz, P.E., & Blazevich, A.J. (2008). Physical performance and cardiovascular responses to an acute bout of heavy resistance circuit training versus traditional. *Journal of Strength and Conditioning Research, 22*(3), 667-671.

Romero, S., Martinez, M.P, & Alcaraz, P.E. (2013). Impact of resistance circuit training on neuromuscular, cardiorespiratory adaptations and body composition in the elderly. *Aging and Disease, 4*(5), 256-263.

Temple, V.A., Frey, G.C., & Stanish, H.I. (2006). Physical activity of adults with mental retardation: Review and research needs. *American Journal of Health Promotion, 21*(1), 2-12.

Tsimaras, V.K., Giamouridou, G.A., Kokaridas, D.G., Sidiropoulou, M.P., & Patsiaouras, A.I. (2012). The effect of a traditional dance trainingprogram on dynamic balance of individuals with mental retardation. *J Strength Cond Res, 26*, 192-198.

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

Wirat, S., Pratoom, M., & Sootmongkol, A. (2017). The Effects of a Circuit Training Program on Muscle Strength, Agility, Performance and Cardiovascular Endurance Anaerobic. International Journal of Physical Education, Sports and Health, 11(4), 176-179.