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Effects of Motor-Games-Based Concurrent Training Program on Body Composition Indicators of Chilean Adults with Down Syndrome

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Abstract: Background: Concurrent training of strength and endurance has been widely ued in the field of health, with favorable effects on body composition. However, the effect on the body composition of a ludic-motor concurrent proposal in adults with Down syndrome has not been quantified yet. The aim of this study was to determine the effect of a concurrent training program based on motor games on body composition indicators and cardiometabolic risk on schooled male adults with Down syndrome. Methods: The sample is composed of 15 male adults with Down syndrome from Chile. Body composition variables such as body mass index, waist circumference, height to waist ratio, skin folds, perimeters, and muscle areas were assessed at the beginning and end of the program. Subsequently, a program of motor games was designed and implemented for 10 months. Results: Mean and standard deviation for body fat were pre (25.36 ± 5.60) and post (23.01 ± 6.20)%; waist circumference pre (86.00 ± 8.97) and post (82.07 ± 8.38) cm. Brachial perimeter and muscle area were pre (22.30 ± 2.80) and post (23.61 ± 2.28) cm; pre (40.19 ± 10.09) and post (44.77 ± 8.48) cm^2, respectively. Our findings showed significant results ($p < 0.05$): body fat %; sum of folds; waist circumference; height to waist ratio; brachial perimeter and brachial muscle area. Conclusion: A concurrent training program implemented through motor skills games decreases body fat and cardiovascular risk and increases the muscle mass in male adults with Down syndrome.

Keywords: intellectual disability; combined training; anthropometry; cardiovascular risk; physical health

1. Introduction

Chile is the country that presents the highest rate of Down syndrome (DS) births in Latin America [1], achieving a prevalence of 2.2 cases per 1000 of births [2]. In this country and in the world, not only has the amount of DS births risen, but also the life expectancy of these people. People with intellectual disabilities are not alien to the demographic transition process; in the last 30 years, the life expectancy of people with DS has increased from 25 to 60 years on average [3]. This situation poses an important challenge to educational establishments and public health structures, which need to generate strategies for well-being and quality of life for this segment of the population.

Adults with DS present an important number of morbidities and behaviors that inversely relate with health outcomes. Having this genetic disorder is related to an increment in cardiovascular risk, sedentary lifestyle, and obesity [4]. The highest indexes of overweight and obesity are present in this population from early ages, achieving digits that oscillate between 32% and 50% [5], while during adulthood these numbers are higher, with only 2 out of 10 adults with DS presenting a normal weight condition [6].

The high levels of adiposity associated with metabolic disorders in people with DS increase the risk of developing insulin resistance and diabetes mellitus 2 [7], decrease the basic metabolic rate, increase leptin concentration (the hunger and satiety regulation hormone), and cause hypothyroidism and a lower development of muscle mass [8]. All these factors have a negative effect on the organic function and on the functional capacity of people with DS, reducing their energetic efficiency and physical condition, which translates into lower levels of muscular strength and cardiovascular resistance [9]. As a proposal to address all these problems, different training methodologies have been suggested, which seek the improvement of physical condition, functionality and autonomy, with the purpose of preventing and/or diminishing co-morbidities associated with the syndrome. One of the most applied methodologies is concurrent training [10], also denominated mix or combined training, which combines strength exercises with cardiovascular resistance training in the same training session or inter-sessions. Interventions employing this methodology have demonstrated benefits for the physical condition and overall health of people with DS. The results of these field studies in people with DS reveal positive findings on ventilation and vagal tone in submaximal works [11], improvements in effort tolerance in maximal and submaximal intensity exercises [12], and an increase in free fat mass, with no significant changes in muscle mass [13]. The results of a 12-week intervention indicate a significant reduction in body fat percentage in adolescents with DS [14]. On the other hand, no significant changes in the percentage of body fat of adolescents with DS were found after the application of two protocols of physical exercises of strength v/s endurance in a 12-week period [15]. Recent evidence is somehow contradictory regarding the structural adaptations and body composition changes on people with DS.

There is no consensus on physical exercise prescription and its effects on people with DS health. Therefore, the suitability of different programs and methodologies and their ability to generate chronic adaptations on a cardiovascular and muscular level have been questioned [16]. Adults with DS do not meet current physical activity recommendations in the United States [17]. In Chile, there are not enough studies on inclusion issues in physical activity to guide its prescription [18]. However, professional orientation should make efforts to promote and reduce barriers in order to stimulate the practice of physical exercise to improve health and wellbeing, as well as to reduce diseases and sedentary behavior.

Different strategies for physical exercise interventions in people with DS should be dynamic, with attractive activities that create high motivation to improve the adherence to a regular and systematic practice of physical exercise in formal or non-formal educative contexts. It is here that games and their different methodologies [19] acquire a leading role as didactic and pedagogic resources to improve physical activity and motility in people with DS [20]. Farías et al. [21] offer a different vision, albeit complementary, about motor games. In this approach, motor games can be quantified and structured in multiple alternatives, like any training program with the aim of using them as an instrument to prescribe exercise, seeking specific goals related to bioenergetic and metabolic needs and how these are related to health in terms of sport and motor aspects, being useful not only as pedagogic and didactic resources but also as a strategy for the adherence of people with DS and their families to physical exercise programs.

After the bibliographic review exposed and the presentation of the importance of the practice of physical activity games in people with DS, this study intends to open a new research path, given the deficiency of studies that exist in the scientific community on this subject, as indicated [20]. The concurrent exercise programs for people with DS reported in the scientific literature use different methodologies for implementation, some of them require expensive infrastructures, such as the use of variable resistance machines and treadmills [15] and swimming pools [14], and others use simple devices such as elastic bands and medicine balls used in training circuits [13]. In addition to the above, the main studies in this population favor neuromotor aspects over metabolic ones [22].

The originality of this study and its novelty is supported by the fact that current scientific evidence is scarce as regards the use of "structured motor games" programs as resources for collective training, that use the support of families and quantify the impact in body composition and cardiometabolic risk applied to schooled adults with DS. The aim of this study was to determine the effect of a concurrent training program based on motor games on body composition indicators and cardiometabolic risk on schooled male adults with DS.

2. Materials and Methods

2.1. Design and Participants

This is a before and after, non-controlled study. A total sample of 15 schooled male adults with DS, who were selected by convenience, with an average age of 23.1 (±3.5 years) and all belonging to a special school from Santiago de Chile, specifically in the Metropolitan Region, was used. It should be noted that the access to this type of population is limited, since it depends on the degree of deficiency, access to centers, and the reluctance found in families. Regarding the selection process of participants, an informed consent was handed to parents and/or guardians, who voluntarily accepted the student's participation in this study. The study followed all the marked guidelines from the Helsinki declaration [23], which regulates research on human beings. This research has the approval of the ethics committee of the University of Granada, with code 2052/CEIH/2021.

The following inclusion criteria have been considered: attending a special educational establishment on a regular basis, presenting a medical certificate that allows for physical activity with no risk and diagnosis of moderate intellectual disability, attending the experimental sessions accompanied by a tutor from the student's family, and being over 18 years old. The following exclusion criteria have been considered: presenting additional syndromes to DS, presenting diagnosed cardiac pathologies, and/or presenting dependency to perform motor tasks.

2.2. Variables and Instruments

2.2.1. Concurrent Motor Games Program

The concurrent motor games program was carried out for 10 months, with a frequency of 2 sessions per week in alternate days (Tuesdays and Thursdays). The duration of each session was 1 h and 30 min, with a weekly volume of 180 min in total. Each session was delivered by three teachers in the company of each student's guardian, who fulfilled the function of hydration provider, ensuring that the student's basic needs were met, and as an additional focus of motivation, encouraging the pupils to participate actively in the sessions.

The motor games applied in each session were classified as local stress (strength) and systemic (endurance) games. In turn, these two categories were categorized based on their hemodynamic response, measured by the rate pressure product, which is considered a safety marker related to effort intensity and reflects the amount of oxygen consumed by the myocardium, whose estimation is obtained by multiplying the heart rate (bpm) and systolic blood pressure (mmHg) [24]. To control these variables, a digital sphygmomanometer (brand Omron M3, Omron Healthcare, Milton Keynes, UK) was employed.

Figure 1 shows the session's structure and components. The total session time was divided into 6 blocks of 15 min. Letter A corresponds to the warm-up, which was designed according to the session's main aspects, to develop during the blocks of motor games. R1 corresponds to the initial block of strength motor games; E1 to the initial block of endurance games; R2 to the final block of strength motor games; and E2 to the final block of endurance games. The segmented session was always conducted with background music. Letter B corresponds to the cool down, where exercises of stretching and relaxation were applied.

Members of the family group or a guardian were present throughout the training session, motivating the participation during the activities and after each block, and providing hydration to students with 125 to 250 mL every 15 min, according to the guidelines of the American College of Sports Medicine [25]. Additionally, in the same period, one of the teachers assessed, through an image, the perception of effort by means of the modified 4 level Borg scale for young adults [26]. Hydration and effort perception control were always performed expeditiously to guarantee the continuity of the workout session.

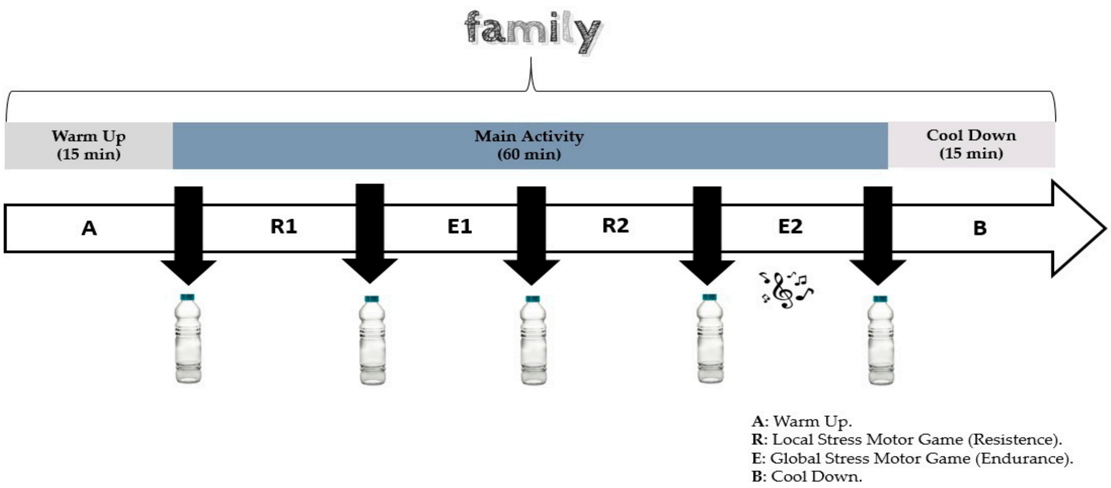

Figure 1. Session structure.

Figure 2 shows the different motor tasks, methods, and systems that were considered to structure the strength and endurance blocks for the implementation of the concurrent motor games program.

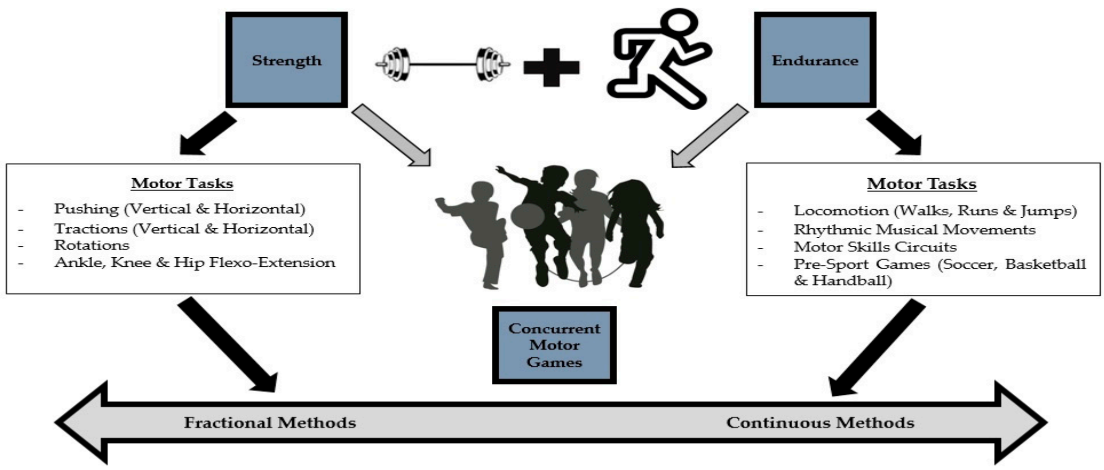

Figure 2. Motor tasks, methods, and systems.

2.2.2. Body Composition Indicators

Body weight (kg) was measured without shoes and with as less clothes as possible. Height (m) was assessed on inspiration adjusting the head in a horizontal plane or Frankfort [27]. For each measurement, a digital weighing machine with stadiometer (SECA mod 206) was used.

Waist circumference (WC) was measured with a measuring tape (brand SECA mod 201) with a precision of 0.1 cm. To assess WC, the middle point between the anterior and superior iliac crests and the tenth rib was considered the anatomic reference. Two measurements were taken into account, and their average was employed to perform the analysis [28].

Body mass index (BMI) was obtained by dividing the body weight (kg) by the height square (m^2), and the waist-height ratio (WHR) was acquired by dividing WC (cm) by the height (cm). It should be underscored that WC, BMI, and WHR are considered anthropometrical markers of cardiovascular risk in people with DS [29].

The body fat percentage was obtained by the equation of Durnin & Womersley [30]. Skinfolds, were measured by a plicometer (Lange Skinfold Caliper®, Beta Technology, Santa Cruz, CA, USA), used by a trained researcher who followed the standardized protocols of the International Society for the Advancement of Kineanthropometry [27].

The brachial muscular perimeter (BMP) and its area (MA) were calculated by the arm circumference (AC) and tricipital skinfold employing the formulas proposed by Frisancho [31].

2.3. Procedure

At a first stage, meetings were held with all principals from the 3 special education schools selected by convenience. Each educational institution informed all students' families about the characteristics of the program and the requisites to participate. Subsequently, interested families were telephonically contacted to participate in a meeting with the research team, in which all questions related to the program stages, pre-participation documentation required, intervention modality, and the different roles to be fulfilled by the research team and by the student's families during the different phases of the intervention were addressed.

The first week of the program was destined to familiarize students with the environment, teachers, and classmates. In weeks 2 and 3 anthropometric measurements were collected from participants. Simultaneously, the team of teachers selected the motor games of strength and endurance to be applied. Week 4 was a pilot week. From the second month on, the concurrent motor games program was carried out for 10 months. Once the period ended, body composition indicators was re-evaluated.

2.4. Statistical Analysis

For the statistical analysis, the Stata® software version 15 was used. Means and standard deviations were used to describe the variables. To contrast data normality and the behavior of the variables, the Shapiro Wilk test was used. Afterwards, a non-parametric test for related samples was applied to compare their means pre and post intervention of the variables: weight, BMI, WC, WHR, AC, MA, BMP, and BF%. For this analysis, the Wilcoxon test was applied. A significance level of 5% was adopted.

3. Results

Results of the descriptive statistic are presented in the Table 1.

The sample described in the previous table (n = 15) participated in at least 65 of the 80 sessions and completed the 10-month program, and measurements of the variables declared before and after the intervention were available. It should be noted that during the development of the program, nine students and their families dropped out of the study and were not considered in the final sample of the study. Two participants deserted due to difficulty in transportation, two due to health problems, four entered late, and one did not state the reasons.

As shown in Figure 3, no differences were observed between weight (Pre = 67.17 $\pm$ 12.13; Post = 66.23 $\pm$ 11.11; $p = 0.06$) and BMI (Pre = 26.74 $\pm$ 3.88; Post = 26.58 $\pm$ 3.79; $p = 0.10$); or in the sum of skinfolds, given by bicipital, tricipital, subscapular, and suprailiac skinfolds (Pre = 96.60 $\pm$ 32.52; Post = 89.87 $\pm$ 39.77; $p <0.001$) and % of body fat (Pre = 25.36 $\pm$ 5.60; Post = 23.01 $\pm$ 6.20; $p = 0.05$) of the students who were intervened with the concurrent motor games program.

Table 1. Sample characteristics (mean [deviation standard]) pre and post intervention.

Variables	Pre (*n* = 15)	Post (*n* = 15)	*p* Value
Height (m)	1.58 ± 0.07	1.58 ± 0.12	0.51
Weight (kg)	67.17 ± 12.13	66.23 ± 11.11	0.06
Body mass index (kg/m^2)	26.74 ± 3.88	26.58 ± 3.79	0.10
Σ Skinfolds (mm)	96.60 ± 32.52	89.87 ± 39.77	<0.001 *
Body Fat (%)	25.36 ± 5.60	23.01 ± 6.20	0.05 *
Bicipital Skinfold (mm)	12.73± 3.24	9.60± 3.25	<0.001 *
Tricipital Skinfold (mm)	19.20 ± 5.77	15.57 ± 5.30	<0.001 *
Subscapular Skinfold (mm)	25.57 ± 7.88	24.37 ± 8,01	0.18
Suprailiac Skinfold (mm)	21.60 ± 10.21	18.33 ± 10.22	0.01 *
Waist Circumference (cm)	86.00 ± 8.97	82.07 ± 8.38	<0.001 *
Waist-Height Ratio	0.54 ± 0.05	0.52 ± 0.05	<0.001 *
Brachial Perimeter (cm)	28.33 ± 2.91	28.50 ± 2.87	0.58
Muscular Brachial Perimeter (cm)	22.30 ± 2.80	23.61 ± 2.28	<0.001 *
Muscular Brachial Area (cm^2)	40.19 ± 10.09	44.77 ± 8.48	<0.001 *

* $p < 0.05$.

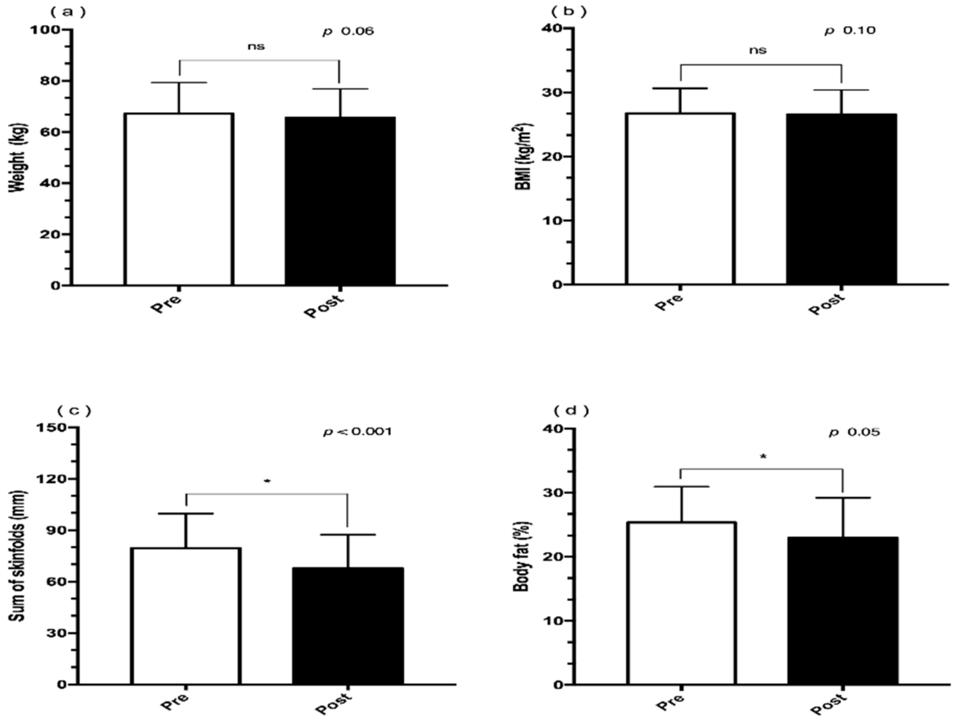

Figure 3. Differences in body weight, BMI, and sum of skinfolds and body fat, pre and post intervention, of the concurrent motor games program (**a**) Body Weight; (**b**) BMI; (**c**) Sum of Skinfolds; (**c**)% Body Fat. Significant differences in all variables (**c**,**d**). BMI: body mass index; Data shown as means and deviation standard; * $p < 0.05$.

Figure 4 reveals individual differences in the bicipital (Pre = 12.73 ± 3.24; Post = 9.60 ± 3.25; $p < 0.001$), tricipital (Pre = 19.20 ± 5.77; Post = 15.57 ± 5.30; $p < 0.001$), subescapular (Pre = 25.57 ± 7.88; Post = 24.37 ± 8.01; $p = 0.18$), and suprailiac (Pre = 21.60 ± 10.21; Post = 18.33 ± 10.22; $p = 0.01$) skinfolds. In all of them a reduction effect is seen on the sample of intervened students.

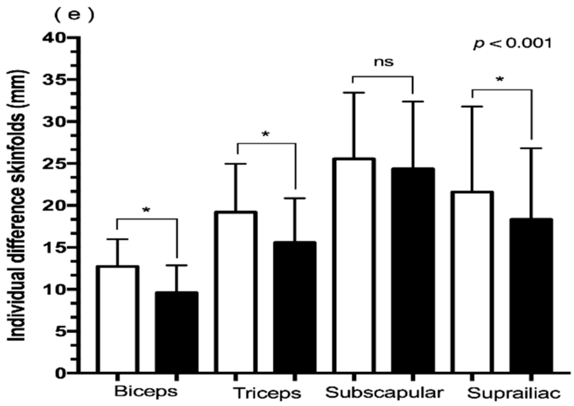

Figure 4. Differences between bicipital, tricipital, subscapular, and suprailiac skinfolds, pre (white color) and post (black color) the concurrent motor games program intervention (**e**). Significant differences are observed for the bicipital, tricipital, and suprailiac skinfolds. Data shown as means; * $p < 0.05$.

Figure 5 shows differences between waist circumference (Pre = 86.00 ± 8.97; Post = 82.07 ± 8.38; $p < 0.001$) and waist to height ratio (Pre = 0.54 ± 0.05; Post = 0.52 ± 0.05; $p < 0.001$) in the intervened sample.

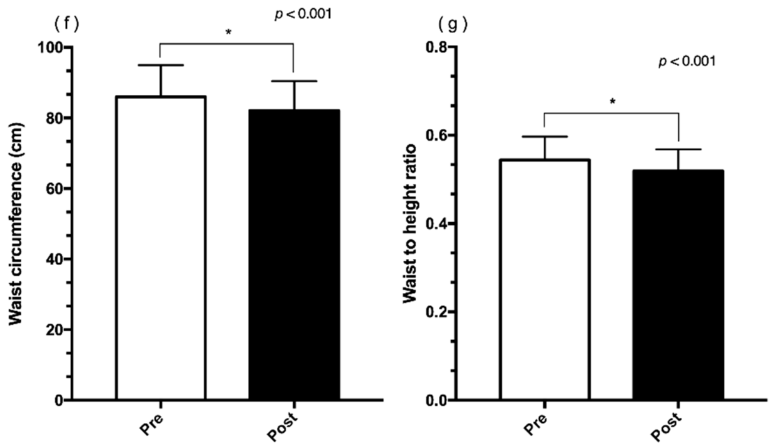

Figure 5. Differences between waist circumference and waist to height ratio, pre and post intervention, of the concurrent motor games program: (**f**) waist circumference; (**g**) waist to height ratio. Significant differences for both variables are evidenced. Data shown as means and deviation standard; * $p < 0.05$.

As shown in Figure 6, no differences were observed between brachial perimeter values (Pre = 28.33 ± 2.91; Post = 28.50 ± 2.87; $p = 0.58$); significant differences were obtained for brachial muscle perimeter values (Pre = 22.30 ± 2.80; Post= 23.61 ± 2.28; $p < 0.001$) and brachial muscle area values (Pre = 40.19 ± 10.09; Post = 44.77 ± 8.48; $p < 0.001$)

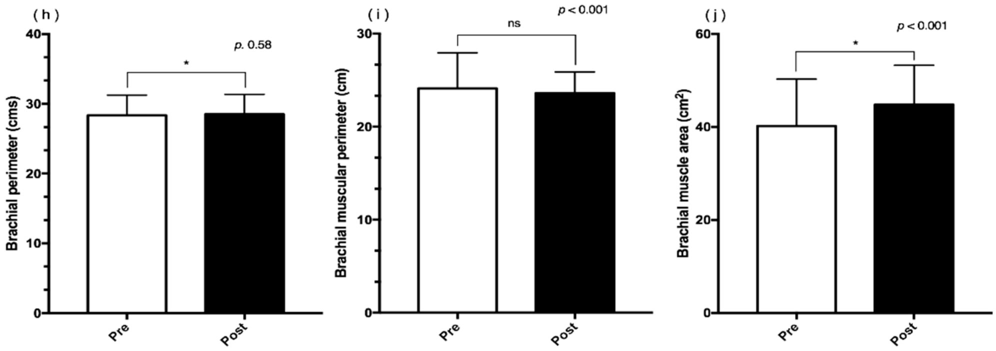

Figure 6. Differences in brachial perimeter, brachial muscle perimeter, and brachial muscle area, pre and post concurrent motor games program intervention: (**h**) brachial perimeter; (**i**) brachial muscle perimeter; (**j**) brachial muscle area. Significant differences are observed for brachial perimeter and area. Data shown as means and deviation standard; * $p < 0.05$.

4. Discussion

Nowadays, concurrent training is a methodological strategy for accomplishing the goals of the exercises for fitness and health, and is able to improve some physical qualities or simply to better and control some health parameters. In this sense, the aim of the present study was to determine the effect of a concurrent training program based on motor games on body composition indicators and cardiometabolic risk in male adults with DS. Our results show that a concurrent training program implemented through motor skills games decreases body fat and cardiovascular risk and increases the muscle mass in male adults with DS.

Rimmer el at. [32], after a concurrent training of 12 weeks applied to 52 adults with DS, did not find significant differences in BMI and BF%. In the same line, Ulrich et al. [33] evaluated 16 subjects who were undergoing a program of education and training on bicycles. The results indicate that it was not possible to establish significant changes in BMI after a 7-week program. However, subjects who succeeded in learning and developing the task for the longest time achieved significant reductions in BF%. These results agree with the changes on body composition generated by our program, which was conducted for a period of 10 months through different motor proposals; this could indicate that the significant changes in BF% are obtained in the long term in this population. In addition, this work not only evidences changes in BF% but also a reduction in WC and WHR, which is related to body fat loss (Table 1). A similar behavior is observed in the study of Davis et al. [34], which assessed the effects of a 16-week protocol for aerobic and strength training on adiposity. This study found that concurrent training combined with nutritional interventions results in a higher reduction in body adiposity. Their results are quite comparable to those of the present study, particularly in relation to the change in BF% and WC.

Rossety et al. [35] assessed the effect of a strength circuit on the systemic inflammation and weight loss of 40 young people with DS for 12 weeks, evidencing that plasmatic levels of leptin, TNF-a, and IL-6 decrease significantly after completing the training program, as well as free fat mass and WC. One of the factors that would explain this weight loss may be the hormone sensitive lipase activation, which modulates the lipolysis mechanism.

The results of this intervention demonstrate significant changes in the adipose and muscle tissue, without evidencing changes in BMI. The findings above confirmed the hypothesis of Pitchford et al. [36], who indicate that it would not be sensible to use this anthropometric marker as an indicator of adiposity or to quantify the effects of the program of physical exercise on the body composition in people with DS. Other anthropometric markers of cardiovascular risk did demonstrate significant improvements. WC decreased by 4 cm on average after the intervention. It is worth noting that this is a reversible condition and its reduction can have excellent effects on the decrease in the risk of cardiovascular and metabolic syndromes [37]. WC is a measure sensitive to changes, and to relate it with the height results in WHR, considered a cardiovascular risk indicator in people with DS. Due to their characteristic condition of high adiposity and lower stature, typical of the syndrome, the cardiovascular risk increases in this population [29].

Moreover, to consider the principles of exercise prescription implies performing a specific activity to generate physiological responses that allow for adapting to the given stimulus—in this case, facilitating the energetic metabolism of fatty acids. The control of these processes during the physical activity is modulated by sympathetic and endocrine stimuli, directly associated with work intensity [38]. The physiological processes previously mentioned could have been triggered by the intervention through sessions of concurrent motor games, and these mechanisms, at the same time, could have been optimized by the hydration strategy given by the methodological proposal. Ritz & Berru [39] indicate that a eu-hydration status can promote the mobilization, transportation, and use of fatty acids by the muscular tissue during an exercise session.

Restructured motor games are considered a pedagogical tool that applies different methodologies according to the objectives to be achieved by the group of students. Following this logic, the findings obtained by Sailema et al. [40] are of interest, as they implemented structured programs of traditional games with positives results in the development of motor skills and functional autonomy in DS. Our intervention has also used games as a method to achieve changes in dimensions related to body composition and cardiometabolic risk, with positive results in the reduction of fat tissue and improvements in muscle tissue through a concurrent motor games program. From the methodological perspective, having involved the families and/or tutors in the development of the sessions and in the whole training program favored the adherence and participation of the study sample. Sollerhed & Hedov [41] point out that to promote physical activity in children and adolescents with DS, it is important to promote and consider the physical activity behavior of parents and siblings, since children with DS depend on family support.

In this sense, the results linked to concurrent training and how it yields positive results in different populations are interesting, as well as their effectiveness, not only in the reduction of fat tissue but also in the increase of muscular tissue. A program of concurrent training applied to elders demonstrates that doing strength exercises before aerobics resulted in greater improvements in muscular tissue and strength in lower limbs [42]. This proposal is remarkably like the methodology applied in this investigation (strength endurance), with similar results regarding appendicular muscle mass gaining, but in the upper limbs. The evidence referring to the effects of concurrent training and the application of several methodologies in people with DS is scarce. A program of 21 weeks of combined training applied to a sample of male and female teenagers with DS, who were intervened through an overload training program, using simple equipment and bodyweight exercises (elastic bands, medicine balls, jumps), obtained results that showed an increment in free fat mass without significant changes in fat percentage [13]. Programs with these characteristics should be incorporated as anticipatory intervention strategies related to health in school contexts, aimed at the prevention of obesity and the deterioration of the physical condition and functional capacity of people with DS, with a view to the world of work [43].

One of the limitations of this study is related to the division of the entire sample into a control and experimental group, due to the small size of the total sample and the influence of diet and the practice of spontaneous physical activity, which only applied to male adults, without considering children or adolescents. Neither was considered to relate the results of body composition and their transference to daily activities, autonomy, and functional independency, which could have been compared with physical condition variables such as cardiovascular and respiratory capacity or muscular strength. Nevertheless, we believe that this is a pioneering study in Chile as well as in the application of this methodology related to concurrent training, which is clearly defined, presented in a friendly layout, and with a didactic nature, through the use motor games. This research sets a precedent in the design of exercise programs for people with disabilities and their families in Chile, can be applied in scholarly and similar contexts, and is easily replicable by educators all over the world, who can adapt it to their realities to improve the wellbeing and quality of life of people with intellectual disabilities.

5. Conclusions

The application of a 10-month structured concurrent motor games program had positive effects on the increase of the brachial muscle perimeter and area and a decrease in waist circumference, height to waist ratio, and body fat tissue, and its consequent impact on the reduction of cardiovascular risk. Despite the above, no significant changes were recorded in BMI. The use of playful strategies that integrate the family is suggested as a methodology in formal and non-formal educative contexts, to facilitate the adherence to a systematic practice of physical exercise and reduce sedentary behavior. Future research that uses this methodology could be aimed at quantifying the impact on physical condition, functionality, and transfer to labor contexts, with the purpose of preventing diseases related to overweight and obesity in adult people with DS.

Author Contributions: C.F.-V., G.A.-S., S.Á.-A., S.E.-L. and C.C.-B. have contributed to the conceptualization. G.A.-S., A.E.-S. and C.F.-V. conceived the hypothesis of this study. C.F.-V., S.Á.-A. and S.E.-L. designed the methodology and drafted the manuscript. All authors contributed to the data interpretation of the statistical analysis. G.F., P.V.-M., G.A.-S. and A.E.-S. wrote the paper with significant input from C.F.-V. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: Regarding the selection process of participants, an informed consent was handed to parents and/or guardians, who voluntarily accepted the student's participation in this study. The study followed all the marked guidelines from the Helsinki declaration [23], which regulates research on human beings. This research has the approval of the ethics committee of the University of Granada, with code 2052/CEIH/2021.

Informed Consent Statement: Not applicable.

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Conflicts of Interest: The authors declare no conflict of interest.

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