Physical Activity in Individuals with Down Syndrome

Subjects: Public, Environmental & Occupational Health | Social Sciences, Biomedical

Contributor: Antonio Muñoz-Llerena , Laura Ladrón-de-Guevara , Daniel Medina-Rebollo , Virginia Alcaraz-Rodríguez

Down syndrome (DS) is the most common genetic alteration in humans, resulting from the trisomy of chromosome 21. Individuals with DS are characterized by physical traits and limitations related to intellectual functioning and the development of motor skills. People with DS tend to have lower levels of physical activity (PA) than the general population, despite its benefits for health and quality of life, which could be caused by barriers such as the lack of adapted programs or knowledge on how to adapt them.

Down syndrome | well-being | adapted physical activity | adapted sports | health | intellectual disability

1. Introduction

1.1. Epidemiology and General Characteristics of Down Syndrome

Down syndrome (DS) is a common genetic alteration resulting from the trisomy of chromosome 21, causing intellectual disability (ID) [1]. Its incidence is approximately 1 in every 700–1200 births [2], with prenatal diagnosis reducing the number of DS births [3][4][5]. Today, people with DS live longer due to advances in medicine and multidisciplinary care, including adapted physical activity programs [6]. Individuals with DS exhibit physical traits and limitations related to intellectual functioning, facial features, hyperlaxity, hypotonia, and other alterations [7][8]. They may have deficiencies in the development of gross motor skills linked to low muscle tone and ligamentous hyperlaxity [9]. DS contributes to delays in the acquisition of motor patterns and the development of atypical patterns [2][10].

1.2. Physical Activity and People with Down Syndrome

Physical activity, understood as an activity which involves people moving, acting, and performing within culturally specific spaces, and contexts, and influenced by a unique array of interests, emotions, ideas, instructions, and relationships [11], is essential for overall well-being and quality of life. However, people with DS tend to be less active due to physical limitations, lack of opportunities, and unawareness of the benefits of physical activity [12]. Physical activity programs can enhance cardiovascular health, muscle strength, motor coordination, balance, and cognitive, emotional, and social skills [13][14]. Despite these benefits, barriers such as a lack of specific programs,

lack of knowledge on adapting physical activities, and negative attitudes hinder the participation of DS individuals [15]. Therefore, it is necessary to have physical activity programs specifically designed for people with DS [13][15], promoting inclusion and active participation [16].

1.3. Autonomy and Quality of Life

Autonomy and quality of life are complex and multidimensional concepts, whose importance for the general population (and, therefore, for people with DS) must be highlighted. On one hand, autonomy is understood as the ability to make decisions about one's own life and live based on those decisions [17][18], including the perception that one is the source of their own actions [18]. Autonomy also includes aspects such as self-care and mobility [19].

On the other hand, following the model developed by Schalock and Verdugo [20], which is the most used in the field of ID, quality of life refers to the degree to which people value their own life experiences, presenting a series of dimensions that contribute to a full and interconnected life within physical, social, and cultural contexts. In short, it is a desired state of personal well-being that: (1) is multidimensional; (2) has universal and culture-bound properties; (3) has objective and subjective components; (4) is influenced by personal characteristics and environmental factors, and (5) is dynamic and changes over time [21][22][23][24][25]. There are eight dimensions of quality of life established in the model of Schalock and Verdugo [20]: emotional well-being, interpersonal relationships, material well-being, personal development, physical well-being, self-determination, social inclusion, and rights.

Both concepts (autonomy and quality of life) are interrelated. Following Schalock and Verdugo [20], autonomy is an intrinsic aspect of the dimension of self-determination within quality of life. However, in this work, it has been highlighted due to its special relevance for the autonomous and daily performance of people with DS.

1.4. Impact of Physical Activity on Quality of Life in People with Down Syndrome

Adapted physical activity programs for people with DS are beneficial in multiple ways. Regular physical activity enhances muscle tone, strength, balance, and motor skills, promoting autonomy and independence in daily activities [26]. It also improves cardiovascular health, body composition, and psychological well-being [27]. Cognitive benefits include enhanced academic performance, cognitive function, attention, concentration, and memory [28][29]. Furthermore, physical activity fosters social integration, quality of life, development of social skills, peer interaction, and friendship bonds [30]. It also boosts self-esteem, self-confidence, and the enjoyment of leisure time [31].

2. Effects of Interventions on Autonomy

- **Cognitive Function**

In relation to behavior, Hojlo et al. [32] showed a decrease in specific symptoms of hyperactivity and impulsivity in almost all participants in the two cohorts of their study, although there were no positive changes in more general behavioral problems (e.g., irritability, agitation, stereotypic behavior, lethargy, and social withdrawal). In contrast,

Perić et al. [33] achieved with their intervention a significant improvement in four psychosocial variables in the experimental group: aggression, attention disorders, anxiety and depression, and social problems, which was not reflected in the control group, where there were no significant changes in any of the four variables. Finally, Ringenbach et al. [34] showed an improvement close to significance for the two experimental groups (resistance training and assisted cycling training) in terms of inhibition control, although the statistical results were not significant.

Regarding cognitive planning and decision making, the qualitative results obtained by Hojlo et al. [32] on goal setting showed that, thanks to the intervention carried out, both participants and parents or tutors began to set goals related to a greater amount of physical activity practice and being healthier. On the other hand, Ringenbach et al. [34] obtained significant improvements in the cognitive planning of participants who participated in the experimental group of assisted cycling training and in the control group (who played board games), as well as a decrease in this variable in the experimental group of resistance training.

- **Functional Mobility and Motor Proficiency**

On the one hand, Kashi et al. [35] obtained significant improvements in the reaction time of participants in their intervention through Kashi practices. On the other hand, the participants in the experimental group in the study by Silva et al. [36] showed significantly improved functional mobility and response speed, variables that did not show significant changes in the control group.

- **Adherence**

Regarding the impact of the intervention on adherence to physical activity practice, Hojlo et al. [32] showed that both participants who repeated the intervention in the second iteration increased their practice of physical activity and sports in their daily life: the first was through daily practice of the DSFit program exercises; the second was by going from not wanting to practice physical activity to signing up for the local Special Olympics basketball team and starting to regularly attend her school gym.

- **Independence**

Within the qualitative results of the study by Hojlo et al. [32], the parents of the 12 adolescent participants considered that the DSFit program favored the latter’s independence and facilitated them to carry out new routines on their own.

Maintaining appropriate levels of muscle strength makes people with DS healthier, helping them live independently and autonomously [35]. However, this population is less active than the general population [10], and, like any person without physical activity habits, they see their levels of sedentary behavior tremendously increased when they reach adolescence, which causes them to stop being able to perform the activities that are carried out in physical education sessions, training, or in tasks of their daily life. This sedentary life exacerbates their health problems, leading to a loss of autonomy when reaching adulthood [15][37]. Therefore, it is essential to know how to design and

adapt physical activities for these people, which must be motivating so that they perceive them as leisure and playful activities and must be adapted to the capabilities. If not, they will cause rejection and, therefore, lack of adherence to the activities. If the activity is not an obligation, it can be maintained over time and produce positive effects on the participants [38], influencing their daily personal performance and quality of life, producing an increase in adherence to the practice of daily physical activity, especially in activities with family members or close people. Therefore, it is recommended that any type of adapted physical activity be carried out, which in the company of family members would be even more beneficial. These results can be attributed to the effects of physical activity on the self-realization and independence of people with DS and those in their close environment [39].

People with DS may need adaptations in activities to promote their involvement. Therefore, organizing adapted activities and providing them with clear and direct instructions can contribute to this type of population being able to participate successfully [40]. In addition to the above, improving inhibition and cognitive planning is essential for carrying out daily life activities, independence, and employment, and one way to favor this aspect is the use of moderate-intensity physical activity [34].

3. Effects of Interventions on Physical Wellbeing

- **Physical Fitness and Psychomotor Skills**

Regarding strength, seven previous studies analyzed the impact of the interventions on the development of strength and power in the lower limbs, upper limbs, core, and respiratory muscles. For the lower limbs, three studies obtained statistically significant improvements in jump length in the experimental group [35][36][37], an improvement that was not observed in the control groups in the studies by Kashi et al. [35] and Silva et al. [36]. In contrast, Ayán Pérez et al. [41] did not observe statistically significant changes in jump length during their intervention. In the case of Hojlo et al. [32] and Moraru et al. [42], improvements were observed in the strength of the lower body in all participants, but they were not statistically significant.

For the upper limbs, Kashi et al. [35] obtained significant improvements in handgrip strength and upper-body muscle endurance in the experimental group, whereas Silva et al. [36] also obtained significant improvements in handgrip strength in the experimental and control groups. On the other hand, the participants of the studies by Ayán Pérez et al. [41] and Benavides Pando et al. [37] did not have significant changes in handgrip strength; the same happened with muscle endurance in the research by Silva et al. [36]. Finally, Hojlo et al. [32] reported improvements in muscle endurance in participants that were not significant.

For core strength, Kashi et al. [35] achieved significant improvements in both trunk strength and core muscle endurance; the same occurred with respect to muscle endurance in two other studies [36][37]. Hojlo et al. [32] and Moraru et al. [42] also obtained improvements in muscle endurance, although these were not statistically significant.

Finally, only one study analyzed the strength of the respiratory muscles [43] by measuring the maximum inspiratory and expiratory pressures, obtaining significant improvements in both experimental groups and significant differences between the experimental groups and the control group and between the two experimental groups (in favor of the group that performed proprioceptive neuromuscular facilitation).

Regarding balance, five studies addressed this variable using different tests. On the one hand, three of them showed positive results: Kashi et al. [35], who obtained significant improvements in the experimental group that were not later reflected in the control group, and Hojlo et al. [32] and Moraru et al. [42], who observed non-significant improvements. In contrast, two other studies [36][37] did not observe significant changes in the balance of the experimental group.

Five other articles assessed the effects of interventions on the aerobic endurance and cardiorespiratory fitness of the participants. Three studies obtained significant improvements in the experimental groups and significant differences between groups in aerobic capacity [36][43] and heart rate [34]. Two other studies showed positive changes in aerobic capacity [32] and cardiorespiratory fitness [41], although they were not significant.

Five investigations analyzed the effects on the speed, agility, and coordination of the participants. Three of these [35][36][37] obtained significant improvements in speed, with differences between the experimental and control groups [35][36]. Furthermore, three other studies showed improvements in the agility of the subjects in the experimental groups, two of which were statistically significant [35][36], and the other did not [41]. In contrast, Silva et al. [36] observed significant differences between the experimental and control groups in upper-limb coordination. These results were similar to those of Benavides Pando et al. [37], although the latter only observed improvements in the right upper limb and not in the left limb. Finally, Perić et al. [33] achieved significant improvements in specific soccer coordination in the experimental group (i.e., ball control with dribbling).

Regarding flexibility and mobility, three studies obtained significant improvements in the experimental group [36][37] and non-significant improvements [32] in lower body flexibility. Hojlo et al. [32] also observed non-significant improvements in the flexibility of the upper body. In addition, a fourth study [42] showed improvements in spinal mobility in all three participants.

Finally, pulmonary function (vital capacity, forced expiratory volume in 1 s, peak expiratory flow rate, and maximum voluntary ventilation) was analyzed by Mohamed et al. [43]. The results showed significant improvements in all variables of pulmonary function in both experimental groups, as well as in vital capacity and peak expiratory flow rate in the control group. In addition, there were significant differences between the experimental and control groups, and between the two experimental groups (in favor of the group that performed proprioceptive neuromuscular facilitation).

- **Anthropometric Measures**

Regarding height, weight, and BMI, none of the five studies reported significant improvements after the intervention [32][36][41][43][44]. The same was true for waist circumference in the study by Ayán Pérez et al. [41], although Silva et al. [36] showed significant improvements in this variable. Of the three studies that analyzed body composition, only two achieved positive changes in the experimental group: one in the percentage of fat mass in the upper limbs [44] and the other in visceral fat [36]. However, none of these changes has been observed with respect to muscle mass [36][41][44]. Finally, only Mohamed et al. [43] evaluated the ratio of the upper to lower chest wall and obtained results similar to the rest of the variables in this study: significant improvements in both experimental groups and in the control group, as well as significant differences between both experimental groups and the control and between the two experimental groups (in favor of the group that performed proprioceptive neuromuscular facilitation).

- **Healthy Habits and Leisure Time Use**

In adults, no changes were observed in daily habits or behaviors during leisure time, and the qualitative results of Hojlo et al. [32] showed that, in young people, exercise and physical activity became an important part of daily and family life. In fact, for one of the girls who repeated the two interventions, having participated in the study allowed her to gain sufficient confidence to sign up for a local Special Olympics basketball team and to regularly attend the school gym.

- **Posture and Baropodometry**

Di Fabrizio et al. [45] reported results which indicated a better distribution of load on both feet and a reduction in podalic overload points, aspects that were related in seven of the participants with an improvement in the angular position of the hip, knee, ankle, and foot joints. These postural improvements were due to lesser anteversion of the pelvis, reduction in knee valgus and hindfoot, and elevation of the plantar arch.

- **Amount of Moderate to Vigorous Physical Activity**

Adamo et al. [40] showed that all three participants increased their MVPA during the intervention and that, when it ended, the MVPA decreased. However, in the second baseline condition of their study, the MVPA did not decrease to the level of the first one. In fact, during the period between the first and second rounds of intervention, the participants carried out some of the activities shown in the videos during the intervention without watching them.

- **General Health, Quality of Life and Wellbeing**

Camacho et al. [46] achieved results that showed significant differences between male and female participants in relation to the quality of life index (in favor of men) in the questionnaires carried out by the informants (e.g., parents, tutors, teachers), as well as a significantly higher quality of life index in the group of athletes compared to the non-athletes (perceived by the participants with DS) and a higher perception of quality of life in the participants than in the informants. However, they also found that the participants did not perceive these significant differences in the quality of life index between men and women, and that the informants did not consider that there were significant differences between athletes and non-athletes.

On the other hand, Ayán Pérez et al. [41] did not find significant changes in the general health of the participants. However, Hojlo et al. [32], in their qualitative results, observed that there was a positive change in the perception of participants and parents related to the importance of maintaining a healthy lifestyle.

The main results on physical well-being showed an increase in physical fitness and psychomotor skills, and specifically in various physical variables (e.g., strength, balance, aerobic endurance, cardiorespiratory fitness, speed, agility, coordination, flexibility, mobility, and pulmonary function) in most of the interventions analyzed. Similar results have previously been reported in the scientific literature on physical activity in DS [31][47][48][49]. However, it is necessary to consider some aspects when implementing physical activity programs in this population. People with DS present many alterations associated with their syndrome, such as muscle weakness, hypotonia, ID, growth retardation in motor development, and a low aerobic capacity [48][50]. In this way, the growth retardation has a direct impact on their learning and control of motor skills [35]. Another important aspect to consider is muscle weakness and hypotonia, very disabling characteristics for people with DS. Therefore, designing adapted physical activity programs facilitates their physical performance and the performance of daily life activities, also improving their health and quality of life [9][16][35][41][51].

Similarly, a greater amount of MVPA can contribute to maintaining cognitive function (e.g., attention, memory) and preventing or delaying the onset of diseases such as Alzheimer's in people with DS [52]. In fact, concern for one's own physical well-being and health is a determining factor in the quality of life in older people who have ID [46].

At the anthropometric level, only some of the analyzed studies showed improvements in waist circumference, fat mass, and the upper-to-lower chest wall ratio. These improvements (and their absence in other variables, such as height, weight, or BMI) are similar to those presented in previous studies [50]. This is consistent with the fact that exercise itself does not lead to significant changes in anthropometric parameters or body weight, although aerobic exercise could produce positive changes in factors related to obesity, and especially aerobic interval training [53].

The physical well-being of people with DS decreases with age, given the accelerated aging that characterizes this population, and that implies experiencing a physical state typical of older people [46]. Therefore, it is essential to design specifically adapted physical activity programs to improve physical well-being and prevent the possible consequences of premature aging and a sedentary lifestyle in this population.

4. Effects of Interventions on Psychological, Cognitive, and Emotional Wellbeing

- **Self-Esteem and Self-Determination**

Hojlo et al. obtained promising qualitative results regarding self-esteem [32]. In the interviews, it was mentioned that one of the participants did not practice sports before starting the intervention due to a lack of confidence, and after finishing she began to trust herself, signing up for a local Special Olympics basketball team and started to regularly

attend the school gym. In contrast, Pérez et al. [41] did not find significant changes in the self-esteem of the participants.

Self-determination was analyzed by Camacho et al. [46], who found significant differences between athletes and non-athletes (in favor of the former) according to the perception of the participants, as well as an absence of differences between sexes (according to participants and informants) and between athletes and non-athletes (only informants). There were also significant differences in this variable between participants and informants (in favor of the participants).

- **Emotional State and Mood**

In adults, Camacho et al. [46] evaluated the differences in emotional state and found that men had a significantly better emotional state than women (observed by participants and informants). According to what was observed by the participants, the same thing happened in athletes with respect to non-athletes (while, for the informants, there were no significant differences), and there were no significant differences between participants and informants in the perception of this variable. In young people, a reduction in anxiety and depression was observed in the experimental group, which in the case of Perić et al. [33] was significant and did not occur in the control group. Hojlo et al. [32] found that this reduction occurred in the majority of participants from both cohorts but was not significant; they also found that both participants and parents increased their interest in practicing exercise as a mechanism for improving mental health.

- **Personal Satisfaction and Development**

In the research by Camacho et al. [46], participants perceived significantly higher personal development values in men than in women and in athletes than in non-athletes, differences that were not significant in the perception of the informants, and there were also statistical differences between participants and informants regarding this variable. However, Pérez et al. [41] did not find significant changes in participant satisfaction after the intervention. Finally, the interviews conducted by Hojlo et al. [32] showed that the intervention served to increase the satisfaction of the participants, and that the key aspects for both participants and parents to feel satisfied were the fun, positive, and social atmosphere of the program; being able to meet other families in the same situation; and practicing walking exercises, with ball throwing, or with music and dance. The only aspect they mentioned that hindered satisfaction was the standing and waiting exercises.

5. Effects of Interventions on Social Wellbeing

- **Interpersonal Relationships**

In children and adolescents, the interviews conducted by Hojlo et al. [32] showed that what the participants enjoyed the most was learning new exercises, being together with other children, and being able to relate to them in the program. In addition, Perić et al. [33] significantly reduced social problems (e.g., arguing with others, getting angry

easily, not being liked by other people, preferring to be alone rather than with others) in the experimental group, a reduction that did not occur in the control group. In adults, the participants in the study by Camacho et al. [46] considered that there were significant differences in interpersonal relationships between athletes and non-athletes (i.e., the group of athletes communicated better with others); these differences were not perceived by the informants. No significant differences were observed in this variable between men and women or between the perceptions of the participants and informants.

- **Social Inclusion and Rights**

Participants in the study of Camacho et al. [46] perceived that there were no differences in social inclusion and rights based on sex, although the group of athletes presented significantly higher values than non-athletes. Furthermore, the informants did not perceive differences in social rights according to sex or in any of the variables depending on whether they were athletes; however, they did present significantly higher values in men in social inclusion. Lastly, there were no differences between participants and informants in the values obtained in the variable of social rights, but there were differences in social inclusion (the participants presented significantly higher values).

6. General Considerations

Well-defined and structured physical activity programs allow for improvements in physical, psychological, emotional, and social well-being, greater motor control, greater autonomy and independence, and performance in functional activities of daily life, avoiding the isolation of people with DS and including them in society [10][13][38], and can be complemented with automated tracking systems of practice or with tools that serve as reminders to maintain adherence to the program [32]. However, although the benefits of practicing physical activity in all dimensions of quality of life are evident, the greatest effects are usually given at the psychosocial level and not at the motor level, since the objective of this type of program is usually to improve general motor coordination to successfully carry out daily life activities, and not specific sports actions [33].

It is also necessary to consider the possible challenges when measuring this type of population, as it is difficult for them to adhere to very strict evaluation parameters, and their lack of motivation or understanding of the instructions during the measurement can affect the measurements made [32].

References

1. Pérez-Chávez, D.A. Síndrome de Down. Rev. Actual Clín. Investig. 2014, 45, 2357–2361.
2. Bittles, A.H.; Bower, C.; Hussain, R.; Glasson, E.J. The Four Ages of Down Syndrome. Eur. J. Public Health 2007, 17, 221–225.

3. Cocchi, G.; Gualdi, S.; Bower, C.; Halliday, J.; Jonsson, B.; Myrelid, Å.; Mastroiacovo, P.; Amar, E.; Bakker, M.K.; Correa, A.; et al. International Trends of Down Syndrome 1993–2004: Births in Relation to Maternal Age and Terminations of Pregnancies. Birth Defects Res. A Clin. Mol. Teratol. 2010, 88, 474–479.
4. Lai, F.M.; Woo, B.H.; Tan, K.H.; Huang, J.; Lee, S.T.; Yan, T.B.; Tan, B.H.; Chew, S.K.; Yeo, G.S.H. Birth Prevalence of Down Syndrome in Singapore from 1993 to 1998. Singap. Med. J. 2002, 43, 70–76.
5. Royston, P.; Thompson, S.G. Model-based Screening by Risk with Application to down's Syndrome. Stat. Med. 1992, 11, 257–268.
6. Hernández-García, C.R.; Luján-Muñoz, I. Equinoterapia. Rehabilitación Holística. Plast. Restaur. Neurol. 2006, 5, 70–74.
7. Gupta, S.; Rao, B.K.; Kumaran, S. Effect of Strength and Balance Training in Children with Down's Syndrome: A Randomized Controlled Trial. Clin. Rehabil. 2011, 25, 425–432.
8. Lizama, M.; Retamales, N.; Mellado, C. Recomendaciones de Cuidados En Salud de Personas Con Síndrome de Down: 0 a 18 Años. Rev. Med. Chile 2013, 141, 80–89.
9. Fox, B.; Moffett, G.E.; Kinnison, C.; Brooks, G.; Case, L.E. Physical Activity Levels of Children with Down Syndrome. Pediatr. Phys. Ther. 2019, 31, 33–41.
10. Case, L.; Ross, S.; Yun, J. Physical Activity Guideline Compliance among a National Sample of Children with Various Developmental Disabilities. Disabil. Health J. 2020, 13, 100881.
11. Piggin, J. What Is Physical Activity? A Holistic Definition for Teachers, Researchers and Policy Makers. Front. Sports Act. Living 2020, 2, 72.
12. Amatori, S.; Sisti, D.; Perroni, F.; Brandi, G.; Rocchi, M.B.L.; Gobbi, E. Physical Activity, Sedentary Behaviour and Screen Time among Youths with Down Syndrome during the COVID-19 Pandemic. J. Intellect. Disabil. Res. 2022, 66, 903–912.
13. Menear, K. Parents' Perceptions of Health and Physical Activity Needs of Children with Down Syndrome. Down's Syndr. Res. Pract. 2007, 12, 60–68.
14. Alghamdi, S.; Banakhar, M.; Badr, H.; Alsulami, S. Physical Activity among Children with down Syndrome: Maternal Perception. Int. J. Qual. Stud. Health Well-Being 2021, 16, 1932701.
15. Barr, M.; Shields, N. Identifying the Barriers and Facilitators to Participation in Physical Activity for Children with Down Syndrome. J. Intellect. Disabil. Res. 2011, 55, 1020–1033.
16. Mosso, C.; Santander, P.; Pettinelli, P.; Valdés, M.; Celis, M.; Espejo, F.; Navarro, L.; Sepúlveda, F. Evaluación de Una Intervención En Actividad Física En Niños Con Síndrome de Down. Rev. Chil. Pediatr. 2011, 82, 311–318.

17. WHO. World Report on Disability; World Health Organization: Ginebra, Switzerland, 2011.
18. Deci, E.L.; Ryan, R.M. Intrinsic Motivation and Self-Determination in Human Behavior; Plenum Press: New York, NY, USA, 1985; ISBN 0-306-42022-8.
19. Mahoney, F.I.; Barthel, D.W. Functional Evaluation: The Barthel Index. Md. State Med. J. 1965, 14, 61–65.
20. Schalock, R.L.; Verdugo, M.Á. Handbook on Quality of Life for Human Service Practitioners; American Association on Mental Retardation: Silver Spring, MD, USA, 2002; ISBN 9780940898776.
21. Rodríguez-Crespo, M.M. Evaluación de La Calidad de Vida En Niños y Jóvenes Con Síndrome de Down. Doctoral Dissertation, Universidad de Salamanca, Salamanca, Spain, 2018.
22. Gómez, L.E.; Alcedo, M.Á.; Arias, B.; Fontanil, Y.; Arias, V.B.; Monsalve, A.; Verdugo, M.Á. A New Scale for the Measurement of Quality of Life in Children with Intellectual Disability. Res. Dev. Disabil. 2016, 53–54, 399–410.
23. Van Hecke, N.; Claes, C.; Vanderplasschen, W.; De Maeyer, J.; De Witte, N.; Vandevelde, S. Conceptualisation and Measurement of Quality of Life Based on Schalock and Verdugo's Model: A Cross-Disciplinary Review of the Literature. Soc. Indic. Res. 2018, 137, 335–351.
24. Schalock, R.L.; Keith, K.D.; Verdugo, M.A.; Gómez, L.E. Quality of Life Model Development in the Field of Intellectual Disability. In Quality of Life for People with Intellectual Disability; Kober, R., Ed.; Springer: New York, NY, USA, 2010; pp. 17–32.
25. Schalock, R.L.; Verdugo, M.A. A Leadership Guide to Redefining Intellectual and Developmental Disabilities Organizations: Eight Successful Change Strategies; Brookes Publishing Company: Baltimore, MD, USA, 2012; ISBN 978-1-5985-7181-3.
26. Norton, M.; Dyches, T.T.; Harper, J.M.; Roper, S.O.; Caldarella, P. Respite Care, Stress, Uplifts, and Marital Quality in Parents of Children with Down Syndrome. J. Autism Dev. Disord. 2016, 46, 3700–3711.
27. Bertapelli, F.; Martin, J.E.S.; Gonçalves, E.M.; de Oliveira Barbeta, V.J.; Guerra-Júnior, G. Growth Curves in Down Syndrome: Implications for Clinical Practice. Am. J. Med. Genet. A 2014, 164, 844–847.
28. Tomporowski, P.D.; McCullick, B.; Pendleton, D.M.; Pesce, C. Exercise and Children's Cognition: The Role of Exercise Characteristics and a Place for Metacognition. J. Sport Health Sci. 2015, 4, 47–55.
29. Faigenbaum, A.D.; Farrell, A.; Fabiano, M.; Radler, T.; Naclerio, F.; Ratamess, N.A.; Kang, J.; Myer, G.D. Effects of Integrative Neuromuscular Training on Fitness Performance in Children. Pediatr. Exerc. Sci. 2011, 23, 573–584.

30. Yeo, G.S.H.; Lai, F.-M.; Wei, X.; Lata, P.; Tan, D.T.H.; Yong, M.H.; Tan, E.T.H.; Kwek, K.Y.C. Validation of First Trimester Screening for Trisomy 21 in Singapore with Reference to Performance of Nasal Bone. Fetal Diagn. Ther. 2012, 32, 166–170.
31. Temple, V.A.; Frey, G.C.; Stanish, H.I. Physical Activity of Adults with Mental Retardation: Review and Research Needs. Am. J. Health Promot. 2006, 21, 2–12.
32. Hojlo, M.A.; Milliken, A.L.; Baumer, N.T.; Davidson, E.J. DSFit: A Feasibility Pilot Study of a Group Exercise Programme for Adolescents with Down Syndrome. J. Intellect. Disabil. Res. 2022, 66, 952–966.
33. Perić, D.B.; Milićević-Marinković, B.; Djurović, D. The Effect of the Adapted Soccer Programme on Motor Learning and Psychosocial Behaviour in Adolescents with Down Syndrome. J. Intellect. Disabil. Res. 2022, 66, 533–544.
34. Ringenbach, S.; Arnold, N.; Myer, B.; Hayes, C.; Nam, K.; Chen, C.-C. Executive Function Improves Following Acute Exercise in Adults with Down Syndrome. Brain Sci. 2021, 11, 620.
35. Kashi, A.; Sheikh, M.; Dadkhah, A.; Hemayattalab, R.; Arabameri, E. The Effect of “Kashi Practices” on the Improvement of Psycho-Motor Skills in People with down Syndrome. Iran. Rehabil. J. 2015, 13, 13–21.
36. Silva, V.; Campos, C.; Sá, A.; Cavadas, M.; Pinto, J.; Simões, P.; Machado, S.; Murillo-Rodríguez, E.; Barbosa-Rocha, N. Wii-based Exercise Program to Improve Physical Fitness, Motor Proficiency and Functional Mobility in Adults with Down Syndrome. J. Intellect. Disabil. Res. 2017, 61, 755–765.
37. Benavides Pando, E.V.; Delgado Valles, C.; Ornelas Contreras, M.; Jiménez Lira, C. Actividad Física En Jóvenes Con Síndrome de Down. Retos 2023, 50, 415–420.
38. Ulrich, D.A.; Burghardt, A.R.; Lloyd, M.; Tiernan, C.; Hornyak, J.E. Physical Activity Benefits of Learning to Ride a Two-Wheel Bicycle for Children with Down Syndrome: A Randomized Trial. Phys. Ther. 2011, 91, 1463–1477.
39. Rimmer, J.H.; Heller, T.; Wang, E.; Valerio, I. Improvements in Physical Fitness in Adults with Down Syndrome. Am. J. Ment. Retard. 2004, 109, 165.
40. Adamo, E.K.; Wu, J.; Wolery, M.; Hemmeter, M.L.; Ledford, J.R.; Barton, E.E. Using Video Modeling, Prompting, and Behavior-Specific Praise to Increase Moderate-to-Vigorous Physical Activity for Young Children with Down Syndrome. J. Early Interv. 2015, 37, 270–285.
41. Ayán Pérez, C.; Cancela Carral, J.M.; Álvarez Costas, A.; Varela Martínez, S.; Martínez-Lemos, R.I. Water-Based Exercise for Adults with Down Syndrome: Findings from a Preliminary Study. Int. J. Ther. Rehabil. 2018, 25, 20–28.

42. Moraru, C.; Hodorca, R.M.; Vasilescu, D. The Role of Gymnastics and Dance in Rehabilitating Motor Capacities in Children with Down Syndrome. Sport Soc. 2014, 14, 102–112.
43. Mohamed, R.A.; Mohamed, E.S.H.; Habshy, S.M.; Aly, S.M. Impact of Two Different Pulmonary Rehabilitation Methods in Children with Down Syndrome. J. Bodyw. Mov. Ther. 2021, 27, 512–521.
44. González-Agüero, A.; Matute-Llorente, Á.; Gómez-Cabello, A.; Casajús, J.A.; Vicente-Rodríguez, G. Effects of Whole Body Vibration Training on Body Composition in Adolescents with Down Syndrome. Res. Dev. Disabil. 2013, 34, 1426–1433.
45. Di Fabrizio, G.; Parisi, M.C.; Crescimanno, C.; Orofino, F.; Frattalemi, M.; Mingrino, O.G.M. Global Postural Evaluation and Motor Treatment in the Subject with Down Syndrome: Clinical Case Reports. In Proceedings of the Journal of Human Sport and Exercise; Universidad de Alicante: San Vicente del Raspeig, Spain, 2021; Volume 16, pp. S938–S962.
46. Camacho, R.; Castejón-Riber, C.; Requena, F.; Camacho, J.; Escribano, B.; Gallego, A.; Espejo, R.; De Miguel-Rubio, A.; Agüera, E. Quality of Life: Changes in Self-Perception in People with Down Syndrome as a Result of Being Part of a Football/Soccer Team. Self-Reports and External Reports. Brain Sci. 2021, 11, 226.
47. Bartlo, P.; Klein, P.J. Physical Activity Benefits and Needs in Adults with Intellectual Disabilities: Systematic Review of the Literature. Am. J. Intellect. Dev. Disabil. 2011, 116, 220–232.
48. Frey, G.C.; Temple, V.A.; Stanish, H.I. Interventions to Promote Physical Activity for Youth with Intellectual Disabilities. Salud Publ. M. 2017, 59, 437.
49. Hardee, J.P.; Fetters, L. The Effect of Exercise Intervention on Daily Life Activities and Social Participation in Individuals with Down Syndrome: A Systematic Review. Res. Dev. Disabil. 2017, 62, 81–103.
50. Matute-Llorente, A.; González-Agüero, A.; Gómez-Cabello, A.; Vicente-Rodríguez, G.; Casajús, J.A. Physical Activity and Cardiorespiratory Fitness in Adolescents with Down Syndrome. Nutr. Hosp. 2013, 28, 1151–1155.
51. Cowley, P.M.; Ploutz-Snyder, L.L.; Baynard, T.; Heffernan, K.S.; Young Jae, S.; Hsu, S.; Lee, M.; Pitetti, K.H.; Reiman, M.P.; Fernhall, B. The Effect of Progressive Resistance Training on Leg Strength, Aerobic Capacity and Functional Tasks of Daily Living in Persons with Down Syndrome. Disabil. Rehabil. 2011, 33, 2229–2236.
52. Ptomey, L.T.; Szabo-Reed, A.N.; Martin, L.E.; Mayo, M.S.; Washburn, R.A.; Gorczyca, A.M.; Lepping, R.J.; Lee, P.; Forsha, D.E.; Sherman, J.R.; et al. The Promotion of Physical Activity for the Prevention of Alzheimer’s Disease in Adults with Down Syndrome: Rationale and Design for a 12 Month Randomized Trial. Contemp. Clin. Trials Commun. 2020, 19, 100607.

53. Salse-Batán, J.; Sanchez-Lastra, M.A.; Suárez-Iglesias, D.; Ayán-Pérez, C. Effects of Exercise Training on Obesity-related Parameters in People with Intellectual Disabilities: Systematic Review and Meta-analysis. J. Intellect. Disabil. Res. 2022, 66, 413–441.