Physical activity and academic performance in people with Trisomy 21. A narrative review

Actividad física y el rendimiento académico en personas con Trisomía 21. Una revisión narrativa

Marta Vega-Díaz[1], Higinio González-García[2*]

[1] Facultad de Educación. Universidad de A Coruña (UDC), España

[2] Facultad de Educación. Grupo de Investigación TECNODEF. Universidad Internacional de La Rioja (UNIR), España

* **Correspondence:** Higinio González García, higinio.gonzalez@unir.net

Short title:
Trisomy 21: physical activity and academic performance

How to cite this article:
Vega-Díaz, M., & González-García, H. (2022). Physical activity and academic performance in people with Trisomy 21. A narrative review. *Cultura Ciencia y Deporte, 17*(53), 133-148. https://doi.org/10.12800/ccd.v17i53.1899

Received: 27 march 2022 / Accepted: 15 june 2022

Abstract

There is an increasing interest in the studies that relate academic performance and physical activity, although most of them do not examine the intellectual disability dimension. The objective of this review is to know the state of art in the literature in relation to down syndrome, physical activity and academic performance. A narrative review was carried out consulting articles located in the databases of Dialnet, Scopus, Google Scholar, Redalyc, ResearchGate and Scielo. The results show that the vital executive functions for high academic performance are altered in people with Trisomy 21 and that exercises where gross motor skills are put into practice manage to enhance them. As conclusions, physical activity decreases the degree of inattention given to irrelevant stimuli and develops memory in people with Down syndrome, but there is no solid evidence that demonstrates its specific and positive action on school grades.

Keywords: physical activity, Trisomy 21, disability, academic performance.

Resumen

Los estudios que relacionan el rendimiento académico y la actividad física están en auge, aunque la mayoría de ellos no abarcan la dimensión discapacidad intelectual. El objetivo de esta revisión es conocer qué suscita la literatura con relación al Síndrome de Down, la actividad física y el rendimiento académico. Se efectuó una revisión narrativa consultando artículos localizados en las bases de Dialnet, Google Scholar, Redalyc, ResearchGate y Scielo. Los resultados demuestran que las funciones ejecutivas vitales para un alto rendimiento académico están alteradas en las personas con Trisomía 21 y que los ejercicios en donde se ponen en práctica las habilidades motrices gruesas logran potenciarlas. Como conclusiones, la actividad física disminuye el grado de inatención prestada ante estímulos irrelevantes y desarrolla la memoria en personas con síndrome de Down, pero no existen evidencias sólidas que demuestren su acción específica y positiva sobre las calificaciones escolares

Palabras clave: actividad física, Trisomía 21, discapacidad, rendimiento académico.

Introduction

Academic performance has always been a topic of great research interest since it is essential to identify the variables that predict educational success (Fajardo et al., 2017). Academic performance is more susceptible to analysis if a reference is made to people with disabilities (Rodríguez, 2015). There is a tendency to conceptualize school performance as a construct, defined mainly by the level of knowledge that a person has, in a subject, and according to their chronological age (González et al., 2012). To objectively quantify school performance, systemic strategies such as evaluation must be used (Lamana-Selva & De-La-Peña, 2018). Likewise, evaluation reflects what the students have learned during their training process (Lamana-Selva & De-La-Peña, 2018).

Among the areas with the highest priority when carrying out an evaluation are linguistic competence (Cejudo et al., 2017) and mathematics (Mello & Hernández, 2019). The evaluation of language (oral and written) is vital, because it is one of the main ways for students to express the knowledge acquired (Ortiz et al., 2020). Therefore, at an educational level, the quantification of the degree to which students receive information (comprehension), expression (use of speech), written language (copying a dictation, legibility in calligraphy and spelling) should not be neglected (Cicres & Llach, 2019; Marcos, 2016). Regarding mathematical competence, academic performance should be evaluated as it is one of the areas where the worst school grades are seen (Mello & Hernández, 2019). In this case, this evaluation is carried out through numerical problems, operations and calculation (Cárdenas, 2018). Bearing this premise in mind, students should always be provided with activities in which to use these arithmetic operations, to develop their creativity (Llamana-Selva & De-La-Peña, 2018).

After having made reference to academic performance and the skills that have the highest priority of being evaluated, it is examined how intellectual disability can affect school success. The term intellectual disability is conceptualized as a significant limitation in cognitive functioning and adaptive behavior (which is expressed in adaptive, conceptual, social and practical skills), and that appears before the age of 18 years old (Cuesta et al., 2019). Directing the spotlight especially on Trisomy 21, commonly referred to as down syndrome, it is a cognitive disability caused by a chromosomal alteration (Díaz-Cuellar et al., 2016; Fernández, 2016).

Intellectual disability does not affect all people with Trisomy 21 in the same way (since there are different degrees of it). Following the DSM-5 criteria, mild, moderate, severe and profound intellectual disability are differentiated (Peredo, 2016). Below are the main characteristics of people with intellectual disabilities depending on their degree of involvement. As such, the criteria of Peredo (2016) are taken into consideration. Beginning with mild intellectual disability, people show some delay in perceptual and motor areas. However, they are quite autonomous when it comes to personal grooming. Also, it is described that this group usually develops sufficient social and communication skills to be able to adapt and integrate into the environment and the workplace. Continuing with moderate intellectual disability, people who present it tend to start speaking significantly late. In addition to this delay in language acquisition, they often show difficulties in expressing and understanding it. As far as autonomy is concerned, they can acquire a certain personal initiative in actions that involve moving around familiar places and routines such as cleaning. From an educational level, they usually have difficulties in subjects and activities that require the use of reading, writing and mathematics. Continuing with severe intellectual disability, this group of people shows a very poor degree of social and personal autonomy. Their psychomotor development and their expressive and comprehensive abilities are highly impaired. In this way, in order to communicate, they usually use an alternative communication system. Finally, people with profound intellectual disabilities are totally dependent when it comes to their routines and personal hygiene. In this sense, their mobility is practically non-existent and they require constant supervision.

Regarding down syndrome, there are individual differences depending on the degree of disability (Esquivel-Herrera, 2015). People with Trisomy 21 are usually found in mild or moderate degrees (Rojas et al., 2016). Regardless of the degree of involvement, there is unanimity that the most affected cognitive processes in this group are information processing, coding, interpretation, elaboration and emission of appropriate responses to environmental situations (Izquierdo, 2015). Furthermore, their limited attention span (by being distracted by irrelevant stimuli) cannot be excluded (Fernández-Olaria, 2018), and memory (difficulties in the tasks of memory consolidation, retrieval and evocation) (Milojevich & Lukowski, 2016).

Besides, some particularities are referred depending on the level of cognitive impairment in Trisomy 21. In line with that, people with mild disability have fewer difficulties in maintaining attention for long periods of time and ignoring irrelevant stimuli than people with moderate disability (Izquierdo, 2015). Despite this, in mild disability distractions are common in which people tend not to differentiate between old and new stimuli. The group with moderate disabilities will experience, in addition to the problems described, difficulties in continuing the activities previously started and carrying out new ones (provided that they require sequencing processes) (Izquierdo, 2015). On the other hand, the inefficiency in the coding processes, interpretation and elaboration of responses in mild disability supposes that these people fail to generalize their learning (Molero & Rivera, 2013). In addition, this group does not have a good capacity for abstraction. This situation is accentuated in people with Trisomy 21 with moderate disability. In addition, they have a limited planning capacity and a high probability of disorientation during the journeys and routes (Gago & Elgier, 2015). Concerning memory, people with mild disabilities have some difficulty processing sensory information and responding accordingly. Similarly, it is complex for them to store information in the short term and spontaneously imagine viable strategies to solve these "dysfunctionalities" (Molero & Rivera, 2013).

Having detailed the disturbances experienced by people with Trisomy 21, it is easy to imagine that they will manifest problems in school success. This happens because attention and memory are superior executive functions essential for high academic performance (López, 2013; Stevens & Bavelier, 2012). In several research projects, a positive relationship has been found between the practice of physical exercise in people with Down syndrome and the improvement of their attention (Maureira & Flores, 2017a; Schott & Holfelder, 2015). Similarly, there is evidence of the correlation between the satisfactory development of gross motor skills and cognitive functions (Schoot & Holfelder, 2015). As a novelty of this work, the action of physical activity on school grades and executive functions that favor school success are examined, specifically focusing on the disability Trisomy 21. Therefore, the objective of this review

is to know what the literature raises in relation to down syndrome, physical activity and academic performance.

Method

The present work consists of a narrative review of the scientific literature on academic performance in people with intellectual disabilities Trisomy 21 and the practice of physical activity. In the search, 58 articles in Spanish, 1 in Portuguese, 1 in Catalan and 20 in English were taken into account. The keywords that structure the conceptual essence of the text are "physical activity", "Trisomy 21", "disability", and "academic performance". Boolean operators "AND", "OR" and quotes have been used. Specifically, the following were used: "physical activity "AND" Trisomy 21", "academic performance "AND" physical activity", "Trisomy 21 "OR" disability" and "physical activity "AND" academic performance in Trisomy 21"

The articles are located in the bases of Dialnet, Google Scholar, Redalyc, ResearchGate and Scielo. An attempt has been made to assess exclusively current articles (publications in the last ten years, that is, since 2012). As exclusion criteria, articles that addressed the topic of practicing physical activity in other syndromes different than Trisomy 21 were eliminated. Also, it was discarded those research in which the study sample were over the age of 20 years old. In addition, the projects that addressed the inclusion of students with different special needs than down síndrome were erased. As inclusion criteria, it was added studies in which academic performance was analyzed in samples of school students with and without Trisomy 21. Finally, it was chosen those research in which the most affected cognitive areas in mild and moderate intellectual disability were examined. (since people with down syndrome are found mostly within these levels).

Trisomy 21: historical perspective and phenotypic aspects

Trisomy 21, commonly known as Down syndrome, is an intellectual disability described by John Langdon Down in 1866 (Fernández, 2016). In 1959, Lejeune, Gautier and Turpin found 47 chromosomes in a culture of fibroblasts in a sample of children with intellectual disabilities (compared to the relevant 46 within a human karyotype) (Díaz-Cuellar et al., 2016). At that time, it was when Trisomy 21 was classified as a chromosomal alteration. Although it mostly occurs due to a trisomy of the Hsa21 chromosome, it can also appear due to chromosomal mosaicism (a chromosome has "normal" cells and Hsa21 cells together; affecting 3% of people with Down syndrome), or due to an unbalanced chromosomal translocation (Díaz-Cuellar et al., 2016).

In the following phrases, will be detailed the main phenotypic features of people with Trisomy 21. Starting with the upper part of the trunk, it is detailed that, in the head, they present mild microcephaly with brachycephaly (Fernández, 2016). The face presents one of the most well-known features by the population, the "almond-shaped" eyes (Contreras et al., 2012). The nose and mouth are small in size, and there is a characteristic lingual protrusion (Vivar et al., 2019). Continuing with the ears, these are also small, have a very folded helix and do not usually have a lobe (Rodríguez et al., 2015). Moving towards the neck, it is usually shorter than the rest of the population (Restrepo et al., 2013). Continuing with the hands and feet, the first ones are small, they present brachydactyly (short metacarpals and phalanges), clinodactyly (crooked fingers) and little development of the middle phalanx of the 5th finger (Vidal et al., 2012). In the foot, there is a cleft between the first and second toes, with an increase in the distance between them (Alarcón & Salcedo, 2012).

Down syndrome and affected cognitive areas

As specified, people with Down syndrome have difficulties in cognitive processes such as processing, coding, interpretation, elaboration and emission of appropriate responses to environmental situations (Izquierdo, 2015). In addition, they experience problems when it comes to generalizing and transferring the learning incorporated (Rojas et al., 2016). Regarding intelligence, a term that is conceptualized as the bio-psychological potential to process information from the cultural environment, and that is useful for solving problems; the group with Trisomy 21 is represented by light or moderate levels (Rojas et al., 2016; Villamizar & Donoso, 2013). Following Gardner's model, there are eight different types of intelligence: musical, logical-mathematical, linguistic-verbal, bodily-kinesthetic, spatial, interpersonal, intrapersonal and naturalistic, and some are more developed than others (Gutiérrez, 2017). Directing the focus of attention to people with Down syndrome, interpersonal and musical intelligence are the most developed, with linguistic-verbal and logical-mathematical being at the opposite pole (Ruíz, 2016). Considering the premise described, it does not seem strange to verify that these people do not understand verbal messages (García, 2017), or are unable to solve calculation problems (Rahmah & Tengku, 2012).

Another area affected in this cognitive disability is attention. It is a neuropsychological function that allows the human being to orient their state of consciousness towards a certain stimulus of reality (Ramos-Galarza et al., 2016). Attention is not a single entity, but rather a multidimensional construct. Therefore, within it, there is focused, sustained, selective, alternating and divided attention (Ramos-Galarza et al., 2016). Focused attention refers to the ability to maintain stable concentration on a stimulus or task (Maureira & Flores, 2017a). This type of attention is practically non-existent in people with Down syndrome (Fernandez-Olaria, 2018). Sustained attention is similar to the previous one (but the attentional focus is maintained for a longer time), during which its levels fluctuate (Chiang et al., 2015; Rivera-Flores & Vera-Álvarez, 2019). Precisely because it is an extension of the focused one, if this was already weak, the sustained one will be even more deficient. Selective attention allows the person to process relevant information from the environment, while suppressing stimuli from another source more irrelevant (Ballesteros, 2014). The ability to inhibit unimportant stimuli is low in people with Down syndrome, so this type of attention will not be very effective (Izquierdo, 2015). Alternating attention implies the possibility of changing the focus of attention from one task to another quickly (Izquierdo, 2015). Divided attention comes into play when people attend to two tasks simultaneously (Maureira & Flores, 2017a). In this sense, divided attention is an extension of the alternant (it was already deficient). Therefore, the divided one will provide even more unsatisfactory results (Izquierdo, 2015).

Finally, memory is mentioned. It is the psychic ability to integrate information from the environment, keep it updated, store it and retrieve it when necessary (Bernabéu, 2017). Following the model of Estudillo (2012), when an external stimulus is perceived, it is retained in sensory memory for a few moments, then it passes to short-term memory and, finally, to long-term memory. Memory is not a unitary system, but there are several types. First, there is sensory memory, which intercepts stimuli from the environment through the senses (Muelas, 2014). Continuing with short-term memory, it stores the

information collected by sensory memory and makes use of learning that is applied in the present moment (Maureira et al., 2015). The ability to process information is practically null in people with down syndrome, so short-term memory will not be highly developed (Izquierdo, 2015). Finally, long-term memory is responsible for consolidating and storing the information learned to retrieve it and use it over time (López et al., 2013). People with Down syndrome have brain alterations that make memory consolidation, recovery and recall difficult (Milojevich & Lukowski, 2016). Within long-term memory, explicit and implicit are differentiated (Izquierdo, 2015). The explicit, in turn, encompasses the episodic and semantic. Episodic memory stores memories, autobiographical events, emotions and personal experiences in their space-time context (Strempler-Rubio et al., 2015). Semantics stores the knowledge of people in the form of words (Navarro et al., 2020). Finally, implicit memory stores knowledge related to motor skills that are acquired with practice, and are automated by repetition (Ramos et al., 2017). This last memory is the one that is better developed in people with Trisomy 21 (Izquierdo, 2015).

Physical activity in Down syndrome and its role on academic performance

The levels of physical activity practice of people with Trisomy 21 were analyzed by multiple research projects (Alghamdi et al., 2021; Barrios et al., 2021; Esposito et al., 2012; Izquierdo-Gómez et al., 2017; Ketcheson et al., 2017; Lama, 2018; Llewellyn, 2016; Matute-Llorente, 2013; Nocera et al., 2018; Oreskovic, 2020; Palma-Mochon, 2020; Pitetti et al., 2013; Shields & Blee, 2012). Several studies verified that there are low levels of physical activity practice among samples with down syndrome (Alghamdi et al., 2021; Esposito et al., 2012; Izquierdo-Gómez et al., 2017). In the study by Alghamdi et al. (2021) carried out with participants between the ages of 3 and 17 years old, it is exposed how families point out as main conditioning factors for the active lifestyles of their children with Trisomy 21 heart problems, obesity, osteoporosis and muscle weakness. This same study shows that another barrier to the practice of physical activity among the group with Down syndrome is the absence of specialists who know how to adapt the exercises to their needs. Also, it is alleged that people with Trisomy 21 often get bored when doing sports and dancing (Alghamdi et al., 2021). In the work of Esposito et al. (2012) carried out with a sample of people with Down syndrome aged between 11 and 20 years old, it was verified that the general tendency toward the practice of physical activity decreases as adolescents get older. In this way, the students with 14 or 15 years old were significantly more sedentary than their peer group with 12 and 13 years old. In addition to less practice of exercise, its intensity also decreases. In this way, the age group of 14 and 15 years old performed less moderate-vigorous physical activity than children aged 8-9 years old and 10 and 11. Finally, in the study by Izquierdo-Gómez et al. (2017) carried out with people between 11 and 20 years old, a significant difference was found in the intensity of physical activity based on gender. Thus, males performed a higher degree of vigorous physical activity compared to female samples.

People with down syndrome have anatomical, physiological, cognitive and psychosocial attributes that predispose them to experience limitations in their physical condition (Pitelli et al., 2013). The situation described leads this group, as specified, to practice low levels of physical activity (Alghamdi et al., 2021; Fernández, 2017; Ketcheson et al., 2017; Matute-Llorente et al., 2013; Shields & Blee, 2012). The adoption of mostly inactive lifestyles by those who manifest this disability means that they fail to benefit from the improvements that exercise provides, such as the reduction in the risk of obesity (Izquierdo-Gómez & Díaz-Cueto, 2017; Ketcheson et al., 2017) and the increase in cognitive functions (fundamental for academic success) (Nocera et al., 2018).

As specified, academic performance is a widely studied construct in the research literature (especially in regard to subjects such as mathematics and language) (González-Valenzuela & Martín-Ruíz, 2019; Mello & Hernández, 2019). However, there are not many studies that specifically address the relationship between cognitive functions and exercise practice in samples with Trisomy 21 (El-Hady et al., 2018; Schott & Holfelder, 2015). The few articles that have really addressed this issue have found that there is a slightly positive correlation between motor control and cognitive ability (Malak et al., 2013; Schott & Holfelder, 2015). Jurgen et al. (2022) determined that there was a positive relationship between the practice of physical activity and academic performance in a sample of children with Trisomy 21 whose ages were between 5 and 6 years old. Another conclusion of this study was that motor activities improved processing speed. A possible explanation for these findings is that physical activity enhances the functions of the cerebellum, an organ involved in motor control and executive functions (planning) (Jürgen et al., 2022). However, the insufficient sense of balance of these children was correlated with difficulties in mental flexibility. Finally, reference is made to the research by Schott and Holfelder (2015), whose authors found that children with Down syndrome who exercised were able to suppress responses to distracting stimuli to a greater extent.

In the following lines, it will be referenced other works in which the role of physical activity on school performance was examined, but in people without down syndrome (in order to establish a comparison between people with and without disabilities) (Carriedo & González, 2019; Faught et al., 2017; Oliveira et al., 2017). In some projects, positive results were obtained regarding the action of the exercise on said performance (Haapala et al., 2018; Oliveira et al., 2017). However, in other studies, no significant differences were found in school grades between sports practitioners and inactive people (Torbeyns et al., 2017). In a study by Oliveira et al. (2017), who worked with 640 students aged 10 to 18 years old during an academic year. The results showed that the most active sample was the one that obtained the best grades in the language subject (Oliveira et al., 2017). Apart from the subjects where linguistic competence is addressed, those that deal with mathematical operations do not usually predict high academic performance (Mello & Hernández, 2019). Haapala et al. (2018), evaluated the relationship between physical activity and the scores obtained in mathematics and language, in 158 students aged 6-8 years old during an academic year. The results showed a positive relationship between the practice of moderate-vigorous physical activity and reading fluency. However, no significant improvements were obtained in the mathematical domain (Haapala et al., 2018). Other researchers who studied the role of sport on arithmetic calculation (and languages), were Resaland et al. (2016). In this case, 1129 students aged 10 and 11 from 57 schools were selected and significant differences were found in the improvement of mathematical operations (Resaland et al., 2016). Despite this, there are also studies where no differences were found between the levels of physical exercise practice and academic performance. In the work of Torbeyns et al. (2017), who worked with a sample of 44 students of 3rd and 4th grade (between 8 and 10 years old, respectively) for 5 months, concluded that no improvement was obtained in any academic discipline in physical activity practitioners.

Finally, it is described that, in cases where academic progress is observed, perhaps it can be explained because exercise improves cognitive functions and increases brain activity (Maureira & Flores, 2017a). More specifically, physical activity favors the ability to maintain selective and divided attention (Maureira & Flores, 2017b). In addition, it also enhances short-term memory (Hawkes et al., 2014; Maureira et al., 2015).

Importance of the students inclusión in the ordinary classroom and in the subject of Physical Education

Some variables negatively influence the inclusion of students with down syndrome in ordinary centers (Ortiz & Reinosa, 2021). Among them, there are the insufficient awareness of families with children without disabilities, the scarce existence of specialized personnel in the centers of this modality (Fernández, 2017) and the bullying of the peer group (Ortiz & Reinosa, 2021). The mothers and fathers of children with Trisomy 21 must assume a socially and politically active role, in which they claim the right of their children to share schooling with those who do not have disabilities (in an inclusive manner and all subjects) (Fernández, 2017). The previous premise is supported by Ortiz and Reinosa (2021), who found that children with down syndrome aged between 2 and 5 years old schooled under an ordinary inclusive regime, experienced improvements in cognition. Specifically, in the aforementioned sample with disabilities, reasoning ability, logical thinking, and creative thinking were enhanced (they were able to learn to discern between what is real and what was imaginary), and short-term memory was improved (they were able to remember names, people, details, facts and places) and attention. This situation was maximized because both, the sample with intellectual disability and the children without it, developed homogeneous school tasks (Ortiz & Reinosa, 2021). In addition, when teachers proposed playful dynamics within the ordinary classroom, students with Down syndrome improved their ability to adapt to the rules of the games (Ortiz & Reinosa, 2021). In works such as those by Pereira-Silva et al. (2018) an improvement in the ability to concentrate and in the behavioral pattern of children with Down syndrome schooled under an ordinary regimen was observed. Other studies emphasize that, under this modality, students manage to improve their skills for active social participation and autonomously (Dessen & Poland, 2014).

With special emphasis on the subject of Physical Education, the literature reveals that the participation of students with Trisomy 21 in this subject provides social benefits, improves their integration and favors the development of moral values (Fernández, 2016; Tanure & Duarte, 2012). In the study by Tanure and Duarte (2012) it is stated that students with Down syndrome did not show interest in interacting with their peers in free time (recess). In this playful time interval, the children with this disability limited themselves to observing how their classmates played. However, the approach of cooperative activities in school physical education facilitated the interrelation and their social integration in the group-class (Tanure & Duarte, 2012). In other works, it was found that educational sport helped the classmates of children with this type of disability to acquire values of tolerance and respect towards them (Fernández, 2016). In addition, physical education promotes the ability to solve problems through motor skills (Fernández, 2016; Pelegrín et al., 2020).

Conclusions

After reviewing the literature, the following conclusions can be drawn. On the one hand, the existence of unanimity of criteria that show alterations in some superior executive functions in the population with Down syndrome (attention and memory). These limitations favor poor school performance. On the other hand, it can be concluded that attention and cognitive functions can improve with the practice of exercise. However, at the school level, no evidence was found that affirms that active lifestyles necessarily provide improvements in school grades in samples with Trisomy 21 disability.

Regarding the significance of the study, this work is useful to publicize the importance of practicing exercise in the group with Down syndrome. This happens because, if there is evidence that, at least, physical activity increases the attention span of these people and stimulates their cognitive processes. Due to this, it could be recommended that, in the matter of school physical education, betting on the implementation of exercises where people with Down Syndrome can make use of their gross motor skills (running, dragging, dancing or climbing). This simple practice could help people with Trisomy 21 automate repeated sequences of actions (improving procedural memory) and also increase their ability to concentrate. Similarly, cognitive flexibility will allow them to quickly shift their focus of attention from one activity to another (improving shifting attention). Finally, inhibitory self-control will help them ignore irrelevant stimuli by curbing their high degree of impulsivity (increasing focused and sustained attention).

Continuing with the limitations of the present study, the difficulty in finding research works focused exclusively on people with Down syndrome, where the studied variables are examined together, should be mentioned. Therefore, it is suggested that other investigations continue working on this line of research. As future lines of research, it could be examined if the exercise produces advantages on the executive functions of planning, cognitive flexibility and inhibitory self-control. Planning supposes the possibility of mentally anticipating the correct way to execute a task or achieve a certain goal. Cognitive flexibility refers to the brain's ability to adapt behavior to changing situations. Lastly, inhibitory self-control is the human ability to inhibit impulsive behaviors. If physical activity exerts a positive action on these higher functions, people with Trisomy 21 will be able to plan the steps to follow during the completion of a calculation problem with greater success (increasing academic performance in mathematical competence). Similarly, cognitive flexibility will allow them to quickly shift their focus of attention from one activity to another (improving shifting attention). Finally, inhibitory self-control will help them ignore irrelevant stimuli by curbing their high degree of impulsivity (increasing focused and sustained attention).

References

Alarcón, Z. A., & Salcedo, CC (2012). Orthopedic disorders in children with Down syndrome. *Revista Española de Pediatría: Clínica e Investigación, 68*(6), 424-428.

Alghamdi, S., Banakhar, M., Badr, H., & Sanaa, A. (2021), Physical activity among children with down syndrome: maternal perception. *International Journal of Qualitative Studies on Health and Well-being, 16*(1), 1-10. http://dx.doi.org/10.1080/17482631.2021.1932701

Ballesteros, S. (2014). Selective attention modulates information processing and implicit memory. *Acción Psicológica, 11*(1), 21-34. http://dx.doi.org/10.5944/ap.1.1.13788

Barrios, A. B., Latorre, R. P. A, Salas, S. J., & Pantoja, V. A. (2021). Effect of physical activity and fitness on executive functions and academic performance in children of elementary school. A systematic review. *Cultura Ciencia y Deporte, 17*(51), 85-103. http://dx.doi.org/10.12800/ccd.v17i51.1699.

Bernabéu, B. E. (2017). Attention and memory as keys to the learning process. Applications for the school environment. *Reidocrea, 3*(17), 16-23. http://dx.doi.org/10.30827/Digibug.47141

Cárdenas, L. J. A. (2018). The evaluation of the Resolution of Mathematics Problems of Secondary School teachers in Colombia. *Educatio Siglo XXI, 36*(3), 123-152. http://dx.doi.org/10.6018/j/349941

Carriedo, A., & Gonzalez, C. (2019). Academic Performance in Physical Education: Academic Aspects versus Physical-sports. *Cultura, Ciencia y Deporte, 14*(42), 225-232

Cejudo, J., Salido-López, J. V., & Rodrigo-Ruíz, D. (2017). Effect of a program to improve linguistic communication skills in Secondary Education students. *Revista de Psicodidáctica, 22*(2), 135-141. http://dx.doi.org/10.1016/j.psicod.2016.11.001

Chiang, H. L, Chen, Y. J., Lo, Y. C., Tseng, Y. I., & Gau, S. S. F. (2015). Altered white matter tract property related to impaired focused attention, sustained attention, cognitive impulsivity and vigilance in attention-deficit/hyperactivity disorder. *Journal of Psychiatry and Neuroscience, 40*(5), 325-335. http://dx.doi.org/10.1503/jpn.140106

Cicres, J., & Llach, S. (2019). What are dictations for? Representations of future primary school teachers. *Didáctica, 31*, 47-63.

Contreras, B. N. C., Tamar, S. A. C., & Mateus, A. H. E. (2012). Genotype-phenotype correlation and molecular analysis in patients with Down syndrome. *Revista de Ciencias de la Salud, 10*(3), 295-305.

Cuesta, J. L., de la Fuente, R., & Ortega, T. (2019). Intellectual disability: an interpretation within the framework of the social model of disability. *Revista de Controversia y Concurrencia Lationoaméricana, 10*(18), 85-100.

Dessen, M. A., & Poland, A. C. (2014). Relationships between family and school. *Paidéia, 17*(36), 21-32

Díaz-Cuellar, S., Yokoyama-Rebollar, E., & Del Castillo-Ruiz, V. (2016). Down syndrome genomics. *Acta Pediátrica de México, 37*(5), 289-296. http://dx.doi.org/10.18233/APM37No5pp289-296

El-Hady, S. S. A, El-Azim, F. H. A., El-Aziem, H. A., & El-Talawy, M. (2018). Correlation between cognitive function, gross motor skills and health – Related quality of life in children with Down syndrome. *The Egyptian Journal of Medical Human Genetics, 19*, 97-101. http://dx.doi.org/10.1016/j.ejmhg.2017.07.006

Esposito, P. E, MacDonald, M., Hornyak, J. E., & Ulrich, D. A. (2012). Physical Activity Patterns of Youth with Down Syndrome. *Intellectual and Developmental Disabilities, 50*(2), 109-119. http://dx.doi.org/10.1352/1934-9556-50.2.109

Esquivel-Herrera, M. (2015). Boys and girls born with Down syndrome: Life stories of fathers and mothers. *Revista Electrónica Educare, 19*(1), 311-331. http://dx.doi.org/10.15359/ree.19-1.17

Estudillo, A. (2012). The involvement of working memory in the mental resolution of arithmetic problems. *Revista Chilena de Neuropsicología, 7*(2), 43-47.

Fajardo, B. F., Maestre, C. M., Felipe, C. E, León del Barco, B., & Polo del Río, M. I. (2017). Analysis of the academic performance of compulsory secondary education students according to thefamily variables. *Educación XXI, 20*(1),209-232. http//dx.doi.org/10.5944/educxx1.17509

Faught, E. L., Ekwaru, J. P., Gleddie, D., Storey, K. E., Asbridge, M., & Veugelers, P. J. (2017). The combined impact of diet, physical activity, sleep, and screen time on academic performance: a prospective study of elementary school students in Nova Scotia, Canada. *Revista Internacional de Nutrición Conductual y Actividad Física, 14*(1), 29-41. http://dx.doi.org/10.1186/s12966-017-0476-0.

Fernández, M. A. D. (2016). General aspects of Down Syndrome. *Revista Internacional de Apoyo a la Inclusión, Logopedia, Sociedad y Multiculturalidad, 2*(1), 33-38.

Fernández, M. A. D. (2017). Down syndrome and physical activity. *Revista Internacional de Apoyo a la Inclusión, Logopedia, Sociedad y Multiculturalidad, 3*(1), 11-11

Fernández-Olaria, R. (2018). *La atención en personas con síndrome de Down.* https://www.downciclopedia.org/neurobiologia/la-attention-in-people-with-down-syndrome.html

Gago, G. L., & Elgier, A. M. (2015). Early development of executive functions: How are they related to communication skills and what are their evaluation methods? *Anuario de Investigaciones, 22*(2), 289-296

García, L. D. (2017). Mathematics and Down Syndrome. *Revista Internacional de Apoyo a la Inclusión, Logopedia, Sociedad y Multiculturalidad, 4*(1), 119-123. https://doi.org/10.17561/riai.v4.n1.10

González, B. C., Caso, N. J., Díaz, L. K., & López, O, M. (2012). Academic performance and associated factors. Contributions of some large-scale evaluations. *Bordón, 64*(2), 51-68.

González-Valenzuela, M. J., & Martín-Ruíz, I. (2019). Academic performance, written language and motivation in Spanish adolescents. *Revista Nacional e Internacional de Educación Inclusiva, 18*(4), 466-473. https://doi.org/10.11144/Javeriana.upsy18-4.rale

Gutiérrez, D. I. (2017). The theory of multiple intelligences in people with Down syndrome. When talent becomes intelligence. *Investigación en Discapacidad, 6*(3), 122-127.

Haapala, E. A., Lintu, N., Eloranta, A. M., Venäläinen, T., Poikkeus, A. M., Ahonen, T., Lindi, V., & Lakka, T. A. (2018). Mediating effects of motor performance, cardiorespiratory fitness, physical activity, and sedentary behavior on the associations of adiposity and other cardiometabolic risk factors with academic performance in children. *Revista de Ciencias del Deporte, 36*(20), 1-8. http://dx.doi.org/10.1080/02640414.2018.1449562

Hawkes, T., Manselle, W., & Woollacott, M. (2014). Cross-sectional comparison of executive attention function in long-term tai chi, meditation, and aerobic fitness practitioners with normal aging versus sedentary adults. *Revista de Medicina Alternativa Complementaria, 20*(3), 178-184. http://dx.doi.org/10.1089/ac.2013.0266

Izquierdo, L. C. (2015). Contribution of memory, metacognition and metamemory to learning in children aged 12-14 years with Down syndrome enrolled in a specific special education center. *Boletín de Estudios e Investigación, 15*, 77-117.

Izquierdo-Gómez, R., & Díaz-Cueto, M. (2017). Young people with Down syndrome and recreational swimming: possibilities towards inclusion. International *Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte, 17*(65), 43-62. http://dx.doi.org/10.15366/rimcafd2017.65.003

Izquierdo-Gómez, R., Martinez-Gómez, D., Esteban-Cornejo, I., Hallal, P. C., García-Cervantes, L., Villagra, A., & Veiga, O. L. (2017). Changes in objectively measured physical activity in adolescents with Down syndrome:

the UP&DOWN longitudinal study. *Journal of Intellectual Disability Research, 6*(4), 363- 3726(4), 363-372. http://dx.doi.org/10.1111/jir.12354

Jürgen, K. T., Holfelder, B., & Schott, N. (2022). Associations of Motor Performance an Executive Functions: Comparing Children with Down Syndrome to Chronological and Mental Age-Matched Controls. *Children, 9*(1), 73. http://dx.doi.org/10.3390/children9010073

Ketcheson, L., Pitchford, A., Hyun-Jin, K., & Dale, AU (2017).Physical Activity Patterns in Infants With and Without Down Syndrome. *Pediatric Physical Therapy, 29*(3), 200-206. http://dx.doi.org/10.1097/PEP.0000000000000397

Lama, B. (2018). Using Physical Activities for Improving Spatial Relations of Students with Down Syndrome. *World Family Medicine, 16*(8), 38-45. http://dx.doi.org/10.5742MEWFM.2018.93487

Llamana-Selva, M. T., & De-La-Peña, C. (2018). Academic performance in mathematics. Relationship with creativity and coping styles. *Revista Mexicana de Investigación Educativa, 23*(79), 1075-1092.

Llewellyn, A., Simmonds, M., Owen, C. G., & Woolacott, N. (2016). Obesity Reviews. Childhood obesity as a predictor of morbidity in adulthood: a systematic review and metaanalysis. *Obesity Reviews, 17*(1), 56-67. http://dx.doi.org/10.1111/obr.12316

López, M. (2013). Academic performance: its relationship with working memory. *Revista Electrónica Actualidades Investigativas en Educación, 13*(3), 1-19. http://dx.doi.org/10.15517/aie.v13i3.12042

López, M. M., Jústiz, G. M., & Cuenca, D. M. (2013). Methods, procedures and strategies to memorize: necessary reflections for efficient study activity. *Revista de Humanidades, 13*(3), 805-824. http://dx.doi.org/10.15517/aie.v13i3.12042

Malak, R., Kotwicka, M., Krawczyk-Wasielewska, A., Mojs, E., & Samborski, W. (2013). Motor skills, cognitive development and balance functions of children with Down syndrome. *Annals of Agricultural and Environmental Medicine, 20*, 803-806. http://dx.doi.org/10.12659/MSM.893377.

Marcos, G. S. (2016). Oral communication. Activities for the development of oral expression. *Ogigia, 20*, 47-67. http://dx.doi.org/10.24197/ogigia.21.2017.47-66

Matute-Llorente, A., González-Agüero, A., Gómez-Cabello, A., Vicente-Rodríguez, G., & Casajús, J. A. (2013). Physical activity and cardiorespiratory fitness in adolescents with Down syndrome. *Nutrición Hospitalaria, 28*, 1151-1155. http://dx.doi.org/10.3305/nh.2013.28.4.6509

Maureira, C. F., & Flores, F. E. (2017a). Effects of physical exercise on attention: a review of recent years. *Revista Ciencias de la Actividad Física, 18*(1), 73-83.

Maureira, C. F., Henríquez, C. F., Carvajal, C. D., Vega, A. J., & Acuña, D. C. (2015). Effects of acute physical exercise on visual short-term memory in college students. *Revista Ciencias de la Actividad Física, 16*(1), 29-35.

Maureira, F., & Flores, E. (2017b). *Principios de neurobiopsicología para estudiantes de educación*. Obrapropia.

Mello, R. J. D., & Hernandez, E. A. (2019). A study on academic performance in Mathematics. *Revista Electrónica de Investigación Educativa, 21*(29), 1-10. http://dx.doi.org/10.24320/redie.2019.21.e29.2090

Milojevich, H., & Lukowski, A. (2016). Recall memory in children with Down syndrome and typically developing peers matched on developmental age. *Journal of Intellectual Disability Research, 60*(1), 89-100. http://dx.doi.org/10.1111/jir.12242

Molero, C. A., & Rivera, U.G. (2013). Down syndrome, brain and development. *Summa Psicológica, 10*(1), 143-154.

Muelas, P. A. (2014). The influence of memory and learning strategies in relation to reading comprehension in primary school students. *International Journal of Developmental and Educational Psychology, 6*(1), 343-350. http://dx.doi.org/10.17060/ijodaep.2014.n1.v6.753

Navarro, M. C., Marmolejo-Ramos, F., Vásquez, V., Carrea, B., Vélez, J., & Mebarak, C. M. (2020). An Exploratory Study for Assessment of Multimodal Semantic Memory in Colombian Children. *International Journal of Psychological Research, 13*(2), 49-58. https://doi.org/10.21500/20112084.4847

Nocera, V., Wozencroft, A., & Coe, D. (2018). A systematic review of the effect of physical activity on cognitive performance in Young people with Down Syndrome. *Home, 17*(4), 27-35. http://dx.doi.org/10.5055/ajrt.2018.0172

Oliveira, T., Pizarro, A., Costa, M., Fernandes, L., Silva, G., Mota, J., & Ribeiro, JC (2017). Cardiorespiratory fitness, but not physical activity, is associated with academic performance in children and adolescents. *Anales de Biología Humana, 44*(4), 309-315. http://dx.doi.org/10.1080/03014460.2017.1308010

Oreskovic, N. M., Cottrell, C., Torres, A., Patsiogiannis, V., Santoro, S., Nichols, D., Moore, C., & Skotko, B. G. (2020). Physical activity patterns in adults with Down syndrome. *Journal of Applied Research in Intellectual Disabilities, 2*, 1-8. http://dx.doi.org/10.1111/jar.12773

Ortiz, D. D. C., Ruperti, L. E. M., Cortez, M. M. E., & Varas, S. A. C. (2020). Language and communication important components for the development of child well-being. *Revista de Investigación en Ciencias de la Educación Horizontes, 4*(16), 450-460. https://doi.org/10.33996/revistahorizontes.v4i16.128

Ortiz, T. T. M., & Reinosa, N. E. (2021). Educational inclusion of children with Down syndrome in regular initial education, Peru. *Revista Cubana de Medicina General Integral, 37*(2), 1-20.

Palma-Mochon, A. (2020). A systematic review about the relationship and benefits between rugby and Down syndrome. *Education, Sport, Health and Physical Activity, 4*(1), 31-48.

Pelegrín, A., León, E., & González-García, H. (2020). Prosocial behaviors in schoolchildren who are fond of sports. *Cultura, Ciencia y Deporte, 15*(43), 121-129.

Peredo, V. R. (2016). Understanding intellectual disability: data, criteria and reflections. *Reflexiones en Psicología, 15*, 101-122.

Pereira-Silva, N. L., De Souza, R.V. C., & Fuentes, M. C. (2018). Family-school relationship and Down syndrome: perspectives of parents and teachers. *Revista de Psicología, 36*(2), 397-426. https://doi.org/10.18800/psycho.201802.001

Pitetti, K., Baynard, T., & Agiovlasitis, S. (2013). Children and adolescents with Down syndrome, physical fitness and physical activity. *Journal of Sport and Health Science, 2*, 47-57. https://doi.org/10.1016/j.jshs.2012.10.004

Rahmah, L., & Tengku, N. (2012). Reading activities using the scaffolding in mel-SindD for Down syndrome children. *Procedia Social and Behavioral Sciences, 35*, 121-128.

Ramos, T., Marques, J., & Garcia-Marques, L. (2017). The memory of what we do not recall: Dissociations and theoretical debates in the study of implicit memory. *Psicológica, 38*, 365-393

Ramos-Galarza, C., Paredes, L., Andrade, S., Santillán, W., & González, L. (2016). Systems of Focused, Sustained and Selective Attention in University Students of Quito-Ecuador. *Revista Ecuatoriana de Neurología, 25*(1), 34-38

Resaland, G. K., Aadland, E., Moe, F. V., Aadland, K. N., Skrede, T., Stavnsbo, M., Suominen, L., Steene-Johannessen, J., Glosvik, O., Andersen, J. R., Kvalheim, O. M., Engelsrud, G., Andersen, L. B., Holme, I. M., Ommundsen, Y., Kriemler, S., van Mechelen, W., McKay, H. A., Ekelund, U., & Anderssen, S. A. (2016). Effects of physical activity on academic performance in schoolchildren: an Active Smarter Kids (ASK) cluster-randomized controlled trial. *Medicina Preventiva, 91*, 322-328. http://dx.doi.org/10.1016/j.ypmed.2016.09.005

Restrepo, C., Correa, L. A., & Velasquez, M. M. (2013). Cutaneous manifestations in patients with Down syndrome. *Asociación Colombiana de Dermatología, 21*(1), 57-68. http://dx.doi.org/10.29176/2590843X.265

Rivera-Flores, G. W., & Vera-Alvarez, A. E. (2019). Computerized intervention to improve sustained attention in a child with ADHD. *Revista de Psicología Clínica con Niños y Adolescentes, 6*(1), 16-22. http://dx.doi.org/10.21134/rpcna.2019.06.1.2

Rodríguez, G. K., Clavería, C. R. A., & Peña, S. M. (2015). Some clinical and epidemiological characteristics of Down syndrome and its impact on the oral cavity. *Revista de Profesionales de la Salud, 19*(10), 1272-1282

Rodriguez, R. J. (2015). Academic performance of students with hearing disabilities who attend compulsory secondary education in the province of Granada. *Revista Nacional e Internacional de Educación Inclusiva, 8*(3), 218-241

Rojas, M. B. I., Moreno, P. L. M., del Valle, C. D., Valdivia, F. D., & Sainz, P. L. (2016). Immunodeficiencies and Down syndrome. *Revista de Ciencias Médicas de Pinar del Río, 20*(3), 389-398

Ruíz, E. (2016). *Todo un mundo de emociones. Educación emocional y bienestar en el síndrome de Down* (1 ed). Editorial Cepe

Schott, N., & Holfelder, B. (2015). Relationship between motor competence and executive function in children with Down syndrome. *Journal of Intellectual Disability Research, 59*(9), 860-872. https://doi.org/10.1111/jir.12189

Shields, N., & Blee, F. (2012). Physical activity for children with Down syndrome. *British Journal of Sports Medicine, 22*, 1-3

Stevens, C., & Bavelier, D. (2012). The role of selective attention on academic foundations. attention on academic foundations: A cognitive neuroscience perspective. *Developmental Cognitive Neuroscience, 2*(1), 30-48. https://doi.org/10.1016/j.dcn.2011.11.001

Strempler-Rubio, E., Vila, J., Alvarado, A., & Angelica, JR (2015). Evaluation of Episodic Type Memory in preschool children using a task with an egocentric perspective. *Revista de Psicología, 24*(2), 1-13. http://dx.doi.org/10.5354/0719-0581.2015.37650

Tanure, A. M. L., & Duarte, E. (2012). The participation of students with Down syndrome in School Physical Education classrooms: A case study. *Artigos Originais, 18*(3), 237-256. http://dx.doi.org/10.22456/1982-8918.26654

Torbeyns, T., de Geus, B., Bailey, S., Decroix, L., Van Cutsem, J., De Pauw, K., & Meeusen, R. (2017). Bicycle desks in the classroom: energy expenditure, physical health, cognitive performance, brain function, and academic performance. *Revista de Actividad Física y Salud, 14*(6), 429-439. http://dx.doi.org/10.1123/jpah.2016-0224

Vidal, R. C. A., Pérez-Salazar, M. D., Vazquez-Vela, C. C., & Castañeda, L. P. (2012). Most common congenital anomalies of the hand. *Revista Mexicana de Ortopedia Pediátrica, 14*(1), 5-11

Villamizar, G., & Donoso, R. (2013). Definitions and Theories about intelligence. Historical Review. *Psicogente, 16*(30), 407-423.

Vivar, V. P., Riveros, F. F., Sepúlveda, H. G., Pérez, F. M. A., & Fierro, M. C. (2019). Early treatment of orofacial alterations with physiotherapy and palatal plate in children with down syndrome. *Revista de Odontoestomatología, 21*(34), 46-55. http://dx.doi.org/10.22592/ode2019n34a6